EQL Memo No. 21

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Sponsored by
National Science Foundation
Grant No. APR-75-16566 AOI

and

Energy Research and Development Administration
Grant No. EY-76-G-03-1305

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ABSTRACT

This report is concerned with the escalation of capital costs of nuclear central station power plants between the early 1960s and the present. The report presents an historical overview of the development of the nuclear power industry and cost escalation in the industry, using existing data on orders and capital costs. New data are presented on regulatory delays in the licensing process, derived from a concurrent study being carried on in the Social Science group at Caltech.

The conclusions of the study are that nuclear capital costs have escalated more rapidly than the GNP deflator or the construction industry price index. Prior to 1970, cost increases are related to bottleneck problems in the nuclear construction and supplying industries and the regulatory process; intervenors play only a minor role in cost escalation. After 1970, generic changes introduced into the licensing process by intervenors (including environmental impact reviews, antitrust reviews, more stringent safety standards) dominate the cost escalation picture, with bottlenecks of secondary importance. Recent increases in the time from application for a construction permit to commercial operation are related not only to intervenor actions, but also to suspensions, cancellations or postponements of construction by utilities due to unfavorable demand or financing conditions.

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COST ESCALATION IN NUCLEAR POWER*

EXECUTIVE SUMMARY AND CONCLUSIONS

Rarely in the history of United States industry has there been a rags-to-riches-to-rags story as dramatic as that of the nuclear power industry. Just twenty years ago, the AEC was subsidizing the construction and operation of small prototype reactors, pursuing a goal mandated for it by the Atomic Energy Act of 1954, to promote a viable nuclear power industry. By the early 1960s, the technical capabilities of nuclear power had been demonstrated, but it was generally agreed within industry and the government that nuclear power would not be economically competitive with fossil fuel until the 70s. Then between 1963 and 1966, the two major reactor manufacturers, General Electric and Westinghouse, promoted nuclear power through fixed-price (turnkey) contracts at capital costs that made nuclear power competitive with coal for much of the nation. Orders for nuclear units soared during 1966 and 1967, followed by a trough in 1969. A second wave of orders hit the reactor manufacturers in the early 70s, peaking in 1973.

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*Research underlying this paper was supported in part under a grant from the National Science Foundation, APR-75-16566 AOI, in part under funds provided by the California Energy Commission and in part under funds provided by ERDA, EY-76-G-03-1305, EQL Block.

Since 1974, there has been a drastic falling off of new orders accompanied by cancellations of existing orders to the point where net new orders, 1975-1976 totaled minus 9, with 8 additional cancellations in 1977.

Nuclear power which was originally hailed as the ultimate "clean" power source, has become highly controversial. In the mid-1960s the expansion of the nuclear power industry coincided with the growth of the environmental movement, leading to confrontations between utilities and intervenors in the nuclear licensing process. Safety issues and antitrust questions dominated the hearings up to the late 1960s. Then environmental issues came to the fore, leading to a restructuring of the licensing process following the Calvert Cliffs decision in 1971. But recently, an even more fundamental problem has hit the industry. Environmentalists and many neutral observors alike argue that even if nuclear units are safe, and even if nuclear power meets environmental standards, nonetheless nuclear units should not be built because they are simply too expensive relative to other alternatives, particularly coal fired power plants. It is this issue of the cost of nuclear power that is the central topic of this paper.

The basic economic advantage of nuclear power has always been low fuel costs relative to fossil fuel units. The economic viability of nuclear power is currently under attack on the ground that other costs of nuclear power are overwhelming this fuel cost advantage. Specifically, it is argued that:

1. Escalation of capital costs for nuclear units will, if it continues, more than offset the inherent fuel cost advantages of nuclear power.

2. The operating performance of the new large (1000 MWe and over) nuclear units has been poor, resulting in low plant availability factors and high maintenance costs. Coupled with high capital costs per kwh of electricity generated, it is argued that the result is a total cost per kwh greater for nuclear units than for coal units in much of the country.

The discussion of this paper is concerned with escalation of nuclear capital costs, which is well documented in the data available. The argument concerning the operating performance of large nuclear units is still a matter of considerable controversy, in large part because only two or three years of operating experience are available for the typical large unit. In any case, however the argument concerning operating performance is resolved, escalation of capital costs remains a central issue so far as the economics of the nuclear industry is concerned.

Our approach in this paper is historical, summarizing data on the course of development of the nuclear power industry, and examining some of the leading explanations for that course of development. Based on previous unsuccessful attempts by the AEC and others to predict the future course of the industry, it might be well to point out that we do not attempt any such projections here. Instead, we feel that there is a contribution to be made simply by recounting what has happened and attempting to understand that.

We examine in detail the two basic explanations that have been offered for capital cost escalation in nuclear power; namely, first, the argument that cost increases are related to the activities of intervenors in the nuclear licensing process; and, second, the argument that cost increases reflect bottleneck problems in construction, equipment supplying industries, and in the licensing process. As will be developed later, capital cost increases in the nuclear industry far exceed those that would have resulted simply from inflation of the general price level, or even inflation of the construction industry price level. Hence an explanation of the differential rate of escalation of nuclear costs must ultimately rest on characteristics specific to the nuclear industry.

Our general conclusions are these: in the early years of commercial development of the nuclear power industry (1966-1970), the bottleneck hypothesis accounts for most of the cost increases that occurred; but, since 1970, while bottleneck effects are still present, the procedural and substantive effects of intervention in the licensing processes have dominated the cost picture. We develop these conclusions in the course of a narrative description of the economic history of the industry, rather than attempting an explicit statistical treatment aimed at identifying the quantitative importance of these two underlying hypotheses. Data problems relating to small sample size, site specific characteristics of nuclear units, serial and auto correlation, and other related issues argue against the reliability of sophisticated statistical models in the analysis of the cost escalation problem.

The period from the early 1960s to the present has been one of dramatic changes in the technology and costs of power generation, not only in the nuclear industry, but also in coal, oil and natural gas. Moreover, it has been a period during which the federal government has played an increasingly important role in influencing investment decisions by electric utilities. Thus in our analysis of the development of the nuclear power industry, we place special emphasis on the information available to decision makers at the time that decisions were made and how that information was used, rather than judgements as to whether the decisions make sense from the point of view of informed hindsight. With one or two notable exceptions, a rather consistent picture of the period can be constructed using the usual model of the economist, namely that decision makers, whether utilities or reactor manufacturers, tended to make profit maximizing choices based on the best data available, and that the market for nuclear units was relatively responsive to changes in information.

To develop these points, we begin with a brief description of the pattern of growth in nuclear generating capacity and changes in nuclear costs. Then we turn to a detailed description of the economic decisions which created those patterns.

BACKGROUND: THE GROWTH OF NUCLEAR POWER

Table 1 summarizes the statistics on the growth of the nuclear power industry over the period 1955 to 1976. The term NSSS refers to "nuclear steam supply system," the heart of the nuclear unit. As indicated by the final four columns, units ordered up through 1961 were mainly small prototype reactors (capacity of less than 100 MWe), but beginning in 1962, commercial size reactors dominate the picture. The history of the industry has been characterized by a rapid growth in unit size, the typical unit under order being in the 600 MWe range in the mid-1960s in contrast to a typical size of 1000 MWe and more in the mid-1970s. Except for a handful of large coal units, only nuclear plants are built in the 1000 MWe and over range, even today.

Construction and operation of a nuclear plant requires licenses from the AEC (now NRC). The licensing-construction process involves four basic stages: applying for and receiving a construction permit; building under a construction permit until construction is far enough along so that the design is finalized, at which time an operating license application is filed; applying for and receiving an operating license; testing under the operating license until approval is received for operating the plant commercially, under full power. The second pair of columns in Table 1 lists the number and capacity of units attaining commercial status for each year in the 1955-1976 time span. Finally, the last two columns of the table list the installed capacity of the nuclear power industry, figures that reflect both the commissioning of new units and the

TABLE 1

GROWTH OF NUCLEAR POWER

	NSSS Orders			Units Attaining Com'l Status		Installed Capacity	
Year	Orders	Canc.	Net Orders	No.	MWe	No.	MWe
1955	5	--	5	--	----	--	----
1956	2	--	2	--	----	--	----
1957	2	--	2	--	----	--	----
1958	3	--	3	--	----	--	----
1959	1	--	1	--	----	--	----
1960	--	--	--	1	200	1	200
1961	1	--	1	1	175	2	375
1962	1	--	1	1	265	3	640
1963	4	--	4	2	140	5	780
1964	--	--	--	3	50	8	830
1965	7	--	7	1	72	9	902
1966	21	--	21	1	90	10	992
1967	31	--	31	1	40	9	1004
1968	16	--	16	2	1025	10	2007
1969	8	--	8	2	1260	12	3267
1970	15	1	14	3	1796	15	5036
1971	21	1	20	6	3615	21	8678
1972	38	5	33	8	5673	29	14351
1973	37	5	32	7	4513	36	18864
1974	33	11	22	11	9527	46	28351
1975	4	6	-2	10	8837	56	37188
1976	3	10	-7	3	2627	59	39815

Source: Status of Central Station Nuclear Power Reactor, Significant Milestones, ERDA-30, July 1976, and Electrical World, 1965-1977.

decomissioning (or shutdowns) of older units.

There is a pronounced cyclic character to orders for NSSS's, a feature common to all capital goods industries. This leaves it at least open to question whether the recent falling off of orders is simply a hiatus before a new cyclical revival, or whether the decline signals a permanent bottoming out of orders.

The rate of growth in installed capacity has been impressive, with capacity doubling approximately every two years over the 1966-1976 period. Moreover, it is clear that whatever is the long term economic picture for nuclear power, units already in the pipeline will result in large increases in installed capacity for a number of years to come. As of the end of 1976, there were 59 nuclear units operating to produce power in the United States; and as of July 1976, there were 134 units (with average size perhaps 50 percent larger than the average of installed units) in the construction-licensing pipeline.

Table 2 identifies the number of units at various stages of the licensing-construction process as of July 1976, and during earlier periods. Units already in the pipeline would increase nuclear generating capacity over its present level by something on the order of 300 percent, over the next five to ten years. About half of those units are still awaiting construction permits, and others are in early stages of construction. Units in the early stages of licensing and construction can be, and have been, canceled or deferred. Consequently, the backlog is not an irreversible commitment to nuclear power, although construction of many units is so far advanced that outright cancellation is unlikely. Appendix C to this paper provides

TABLE 2

BACKLOGS IN THE LICENSING-CONSTRUCTION PROCESS
(UNITS IN EACH PROCESS AT END OF YEAR)

Year	CP	Primary Construction	OL	Testing For Commercial	Total
1955	2	--	--	--	2
1956	1	3	--	--	4
1957	--	4	--	--	4
1958	1	3	2	--	6
1959	6	3	--	2	11
1960	1	8	2	--	11
1961	1	3	7	--	11
1962	1	1	3	6	11
1963	2	2	2	5	11
1964	1	4	1	4	10
1965	4	3	3	2	12
1966	15	7	3	2	27
1967	26	17	4	4	51
1968	15	31	13	1	60
1969	19	30	17	3	69
1970	27	26	26	6	85
1971	35	14	37	3	89
1972	33	18	36	1	88
1973	47	24	32	6	109
1974	67	40	25	9	141
1975	65	48	25	2	140
July 1976	60	48	24	2	134

Source: Status of Central Station Nuclear Power Reactors, Significant Milestones, ERDA-30, July 1976.

details on orders, cancellations and delays in the licensing-construction process.

The increase in the reported cost of nuclear power plants has been as dramatic as the growth of the nuclear industry. Units coming on line in the late 1960s and early 1970s had reported costs in the range of $150 per kilowatt; by 1976 reported costs for units coming on line had increased to $560 per kilowatt. Thus, capital costs ($/kw) of nuclear units have increased by approximately 300 percent over the 1968-1976 period, while the general price index has increased by "only" 67 percent.[1] However, it is important to emphasize that "reported" costs in the early years (1968-1971) almost certainly understated the true costs for the units coming on line during that period, so that cost comparisons involving these early years are next to worthless. But even when the early years are ignored, the rate of increase in capital costs for nuclear units far outstrips the rate of general inflation. Table 3 summarizes data on capital costs using both FPC and AEC/ERDA figures (see Appendix A for details). The period 1968-1971 is dominated by the so-called "turnkey" plants, where reported costs (by utilities) are generally agreed to be far less than costs incurred (by reactor manufacturers) in the construction of these units. To identify the factors responsible for increasing costs and to explain how the nuclear power industry continued to grow for a time in the face of substantial cost increases, a more detailed account of the economic history of nuclear power is required. We begin with a discussion

TABLE 3

REPORTED CAPITAL COSTS OF
NEW NUCLEAR UNITS
1968-1976
FPC AND AEC/ERDA

Year	Capital Cost $/kw FPC Avg.	FPC Range	AEC/ERDA Avg.	AEC/ERDA Range
1968	164	153-180	192	165-228
1969	215	163-262	205	157-247
1970	138	114-161	127	116-155
1971	146	101-185	139	109-169
1972	188	121-353	217	122-333
1973	251	161-393	240	184-383
1974	362	258-546	329	184-504
1975	n.a.		428	251-518
1976	n.a.		560	415-692

Sources: FPC, Steam Electric Plant Construction Cost and Annual Production Expenses, 1968-1974; AEC/ERDA, Central Station Nuclear Plants, selected issues 1968-1977 of the turnkey period, during which construction of the first large (over 400 MW) commercial reactors commenced.

THE TURNKEY ERA, 1963-1966[2]

The Atomic Energy Act of 1954 provided a mandate for the AEC to develop and regulate a commercial nuclear power industry. The first stage in this effort was a program of research and development activities designed to identify commercially viable reactor types. This program, designated as the Power Reactor Demonstration Program (PRDP), involved partial AEC financing (in collaboration with utilities) of a number of small reactors between 1955 and 1961. By 1962, the LWR (light water reactor) had been established as the most immediately promising of the reactor types, with the breeder reactor and gas cooled reactor still at a development stage.

The problem with the LWR was that capital costs for the small units that had been constructed under PRDP were too high to provide competitive generating costs relative to fossil fuel power plants. Commercialization of the LWR required a move to larger capacity units, say in the 200-400 MWe and over range, where capital costs per kw were expected to show a sizeable drop. But utilities were not willing to undertake the risks of financing such plants, and when the AEC showed no inclination to subsidize plants of this size, orders for reactors simply ceased. At this point, in 1962, the Joint Committee for Atomic Energy stepped into the picture by specifically earmarking $20 million of previously appropriated AEC funds for design and research and development assistance to subsidize construction of commercial size LWRs.

Two reactors were financed in part by the AEC under this new authorization, the last two LWRs to receive government assistance -- Connecticut Yankee (NSSS order in December 1962) and San Onofre 1 (NSSS order in January 1963). Both of these units were built by Westinghouse, and both were built under so-called "turnkey" contracts. Turnkey contracts were contracts under which the builder of the reactor took on all of the responsibility for designing and building the unit, including any actions required to meet regulatory guidelines. After the plant had passed through the licensing process, including testing to attain commercial status, the plant was then turned over to the utility for operation. The typical turnkey contract also provided a financial guarantee in the form of a fixed price for the unit, this price to cover all of the costs of construction and licensing, exclusive of interest during construction.

San Onofre and Connecticut Yankee were contracted for at prices to the utility (after deducting the AEC subsidy) of around \$180/kw. This still left a competitive advantage to coal power plants, with capital costs in the \$110-\$160/kw range. Then, in December 1963, came the dramatic announcement that General Electric had agreed to build the Oyster Creek unit for Jersey Central at a turnkey price of \$132/kw, with no AEC subsidy. Added to the known fuel cost advantages of nuclear units, this capital cost was so low that nuclear power was actually cheaper than coal power at Oyster Creek, the first instance of a nuclear unit being built on the basis of economic advantages alone.

For the next two and one-half years, General Electric, Westinghouse and several of the small reactor manufacturers (including General Atomics and Allis-Chalmers) offered turnkey contracts at fixed prices at or near the Oyster Creek level. In all, 13 plants were contracted for on a turnkey basis between December 1962 and mid-1966.[3] Then, in June 1966, GE announced that it would no longer offer complete nuclear power plants on a firm-price (turnkey) basis in the United States (turnkey contracts are still available for foreign orders). As a practical matter, Westinghouse also pulled out of the turnkey business at about the same time, although a formal announcement to this effect was not made until 1971.[4]

The initial response of the utility industry to the Oyster Creek announcement was one of cautious skepticism; only two nuclear units were announced in 1964 and six in 1965. But in 1966, a flood of 23 announcements were made, most after June and most on a nonturnkey basis. This continued into 1967, with 27 more announcements. Whatever else can be said about the turnkey era, it is a fact that for the nuclear power industry it represented a transition from a period of being a heavily subsidized step-child of the AEC to a period of being a vigorous competitor with fossil fuels for base load power plants.

From all reports, the turnkey contracts signed by General Electric and Westinghouse turned out to be first class financial disasters for the two companies. Mooz (1966) cites correspondence with executives of the two companies that indicate combined losses in the range of $1 billion, and there is corroboration for this estimate from the CONCEPT cost model developed by United Engineers and discussed in WASH-1345. Specifically, the comparisons between reported costs (by the utilities) of turnkey units and the WASH-1345 estimated costs (to the contractor) are as follows.

Turnkey Units	Reported Cost	WASH-1345 Estimated Cost	Estimated Loss
		(Millions of Dollars)	
General Electric			
Oyster Creek	$ 91	$ 170	$ 79
Dresden 2, 3	230	413	183
Millstone	97	182	85
Quad Cities 1, 2	250	448	198
Monticello	105	168	63
Totals	$ 773	$1381	$ 608
Westinghouse			
San Onofre	$ 97	$ 131	$ 34
Ginna	83	161	78
Robinson	78	179	101
Point Beach 1, 2	128	329	201
Connecticut Yankee	92	149	57
Totals	$ 478	$ 949	$ 471
Combined Totals	$1251	$2330	$1079

Source: Power Plant Capital Costs, WASH-1345, AEC, October 1974.

The estimated losses presented above should be viewed as, at best, educated guesses, in part because estimates of capital costs prepared by United Engineers for the AEC have not proved to be particularly accurate in the past.[5]

Whatever the exact figures, there seems little doubt that General Electric and Westinghouse lost substantial amounts of money on the turnkey contracts of the 1963-1966 period. And, because the turnkey era was pivotal in the history of the nuclear power industry, it is important to try to understand the motivations of reactor manufacturers and utilities at that time, and how market forces in the nuclear power industry might have operated.

One version of the history of the turnkey era goes something like this.[6] General Electric negotiated the Oyster Creek contract at a time when the nuclear power industry was at a standstill. General Electric engineers expected to take a loss on Oyster Creek, but acted in the expectation that if two other such units could be built, the learning curve would lower construction costs enough so that General Electric could at least break even on three units. Westinghouse was forced to offer contracts at or near the Oyster Creek price by the competitive pressures applied by General Electric. But as construction proceeded, it became clear both to General Electric and Westinghouse that costs would far exceed original estimates, at which point turnkey contracts were withdrawn from the market. However, the effect of the turnkey period on utilities was to create expectations that nonturnkey units would come in at costs near the turnkey prices, so that orders continued to come in for reactors even after the turnkey option was phased out. Whether intended or not, the turnkey era produced the kinds of results associated with a "loss leader" strategy, in terms of expanding demand for nuclear units. As it turned out, the nonturnkey units came on line six to eight years later at costs two to three times higher than turnkey prices, so that both the reactor manufacturers (on turnkey contracts) and the utilities (on nonturnkey contracts) suffered losses deriving from their overly optimistic expectations as to costs.

The main problem with this story of the turnkey era is clear evidence that cost problems with the turnkey units stemmed largely from the post-turnkey period. The reasons cited for cost overruns by Westinghouse in Mooz' study were: (1) a dramatic change in labor costs (annual rate of increase of 30 percent from 1967 on versus a rate of increase of about 5 percent prior to 1967); (2) birth of the environmental movement; (3) increases in licensing costs; (4) decreases in labor productivity. All of these factors came to the fore only <u>after</u> 1966, that is, only after turnkey contracts had already been withdrawn. And there is no evidence of special sources of information available to General Electric and Westinghouse concerning these general economic trends that were not also available to utilities planning nuclear units.

An alternative to the "loss leader" argument as an explanation for the growth in nuclear orders following the turnkey era is as follows. There are certain advantages to utilities from nuclear power that make it a desirable investment even if generating costs are slightly higher for nuclear relative to fossil fuel plants. First, there is a spreading the risk argument: given that a utility is already using coal, oil and/or natural gas units, adding a nuclear unit reduces the vulnerability of a utility to fossil fuel price increases or lack of availability. Second, nuclear is a high capital cost-low operating cost power source. Adding nuclear units increases the rate base of the regulated utility more than would be the case with alternative power sources and hence increases allowed profits for any given level of output. Third, at the time, nuclear power was regarded as a "clean" fuel, and hence would be less subject to problems of siting and pollution control.

These inherent advantages of nuclear power were offset prior to the turnkey era by uncertainties as to capital costs and uncertainties as to the technical feasibility of large nuclear units. The reactor manufacturers had strong incentives to prove out the technology of large reactors in the mid-1960s. They did this, in effect, by engaging in privately financed demonstration projects, subsidizing the building of the turnkey plants. As construction progress was reported on San Onofre and Connecticut Yankee, the concerns of the utilities as to technological risks diminished. Moreover, by the end of the turnkey era, capital costs of coal plants were increasing at the rate of 15 percent or more per year, and there was a general expectation that coal prices would increase in the future, an expectation that was realized in the wake of the mine safety legislation of 1969. Finally, reported costs on the turnkey units under construction (and on nonturnkey units such as Nine Mile Point) were favorable. The point is that there were a number of factors, over and above estimated capital costs of nuclear units, that encouraged utility investments in nuclear units, even after the turnkey era had ended.

As noted earlier, capital costs to electric utilities for the nonturnkey units contracted for in the immediate post-turnkey era were badly underestimated. But even in the face of those under-estimates, it can be argued that, from hindsight, utilities going nuclear at that time might well have made the correct decision. Developments in alternative fuels, especially coal, acted in part to offset the underestimates of nuclear capital costs.

It seems to us that the turnkey era can only be understood in terms of the distinction between technological risks and cost risks. While the reactor manufacturers had incentives to establish the technological feasibility of large nuclear units, since they could capture the rents from a successful demonstration program, the utilities appear to be in a better position to bear cost risks. Turnkey contracts are rare in the history of United States utilities for that very reason. As a permanent fixture of the contracting process, the price quoted for a turnkey contract would have to incorporate an actuarially sound insurance premium against cost increases. The withdrawal of turnkey contracts once utilities were convinced of the technological feasibility of large nuclear units can be interpreted as a return to the historical practices of the industry with the utility bearing cost risks, because self-insurance against such risks was preferable to the "contingency" premium that would have been built into future turnkey contracts.

There are several reasons for this. In the first place, the utilities are regulated monopolists, able to pass through cost increases to customers through rate increases, while the reactor manufacturers were operating in a competitive environment, competing with fossil fuel units and less able to absorb such cost increases. Moreover, there are moral hazard problems in turnkey-type contracts. The utility is interested in obtaining the lowest total cost of electricity possible for its base load plants, but a turnkey contract only provides a guarantee as to the capital cost of the plant. To the extent that there is the possibility of substitution between low capital cost components and low operating cost components, the incentives for the contracting firm under a turnkey contract are to opt for the low capital cost component. Thus there might well be sound economic reasons for a utility to prefer a nonturnkey contract to a turnkey contract, even if the capital cost of the nonturnkey unit is greater than that of the turnkey unit.

We can of course only speculate on the forces that were at work during the turnkey era. One thing is clear, however; by the end of the era, the nuclear industry had established itself as a major force in the future development of electric power in the United States.

THE COMMERCIAL SUCCESS OF NUCLEAR POWER 1966-1970

As the turnkey era ended, commercialization of nuclear power was an accomplished fact. In 1966 twenty plants were ordered, six on turnkey contracts. The remaining reactors, and almost all reactors ordered after 1966, were built by utilities under normal financial arrangements involving contracting with architect-engineers. During 1967, thirty reactors were ordered, but only one was on a turnkey basis. In 1968 and 1969 orders dropped off to fourteen and then seven reactors; by 1970 orders were back up to fourteen.

Nuclear Costs in Contemporary Perspective

Construction of the reactors ordered in 1966 and 1967 on a nonturnkey basis did not begin until at least twelve months after the orders were announced, because of time required for granting of various licenses. Consequently the initial surge of decisions to build nuclear plants occurred with little experience with construction of large nuclear reactors under normal utility contracting procedures. Nevertheless a mood of general optimism about total nuclear costs -- both capital and operating -- appears to have pervaded this industry. *Electrical World* (November 7, 1966) quoted Dr. Alvin Weinberg as saying that reactors ordered during 1966 would produce electricity at a cost of 25 percent less than that of coal, and in mid-1967, TVA Board member Frank Smith described nuclear power as having a clear but somewhat smaller advantage in the TVA area.

There were, however, some warnings that turnkey quotations were unreliable bases for projections of nuclear costs. General Electric's annual report issued in 1967 stated that "earlier commitments made to win customer acceptance of the new [nuclear] technology continue to affect earnings." Stephen F. Dunn, president of the National Coal Association, said that General Electric's annual report illustrated that coal was a more competitive fuel than turnkey prices implied (Electrical World, April 10, 1967).

The trend in actual and estimated nuclear capital costs is apparent from Figure 1. Three time series are plotted in that figure:

1. The average estimated capital costs of all plants ordered in the previous year, as reported by utilities to AEC/ERDA.

2. The average of updated capital cost estimates for all plants still under construction during the previous year (and ordered in years prior to the previous year).

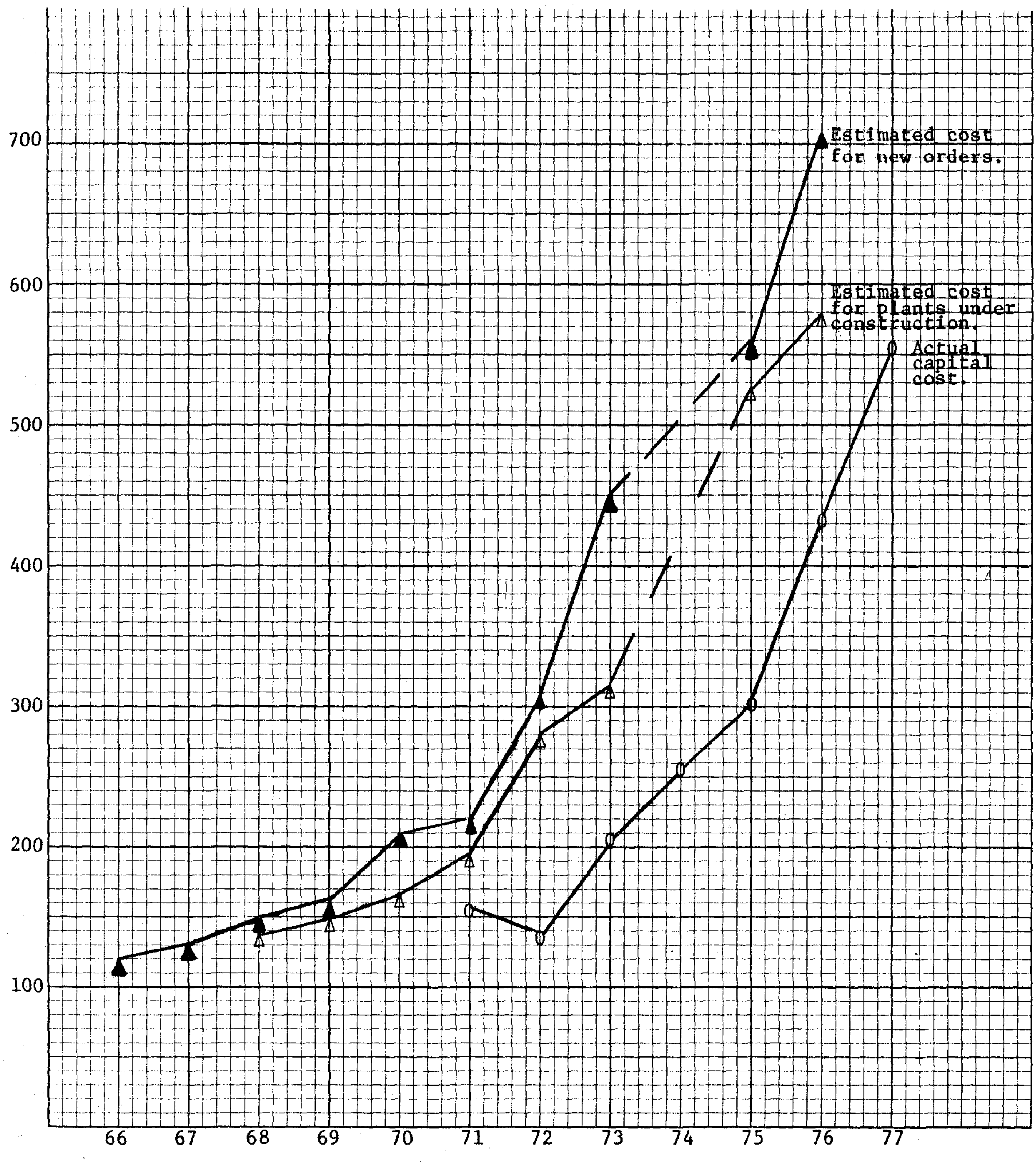
3. The average actual capital cost of all plants completed in the previous year, using AEC/ERDA data.

The same data are displayed in a somewhat different format in Table 4. Complete cost data on a plant by plant basis are provided in Appendix Table A-2. During 1966 and 1967, estimates of nuclear costs appear to have been based on the price quotations for turnkey plants. During 1967 updated estimates of the cost of nonturnkey plants under construction became available. They indicated that actual costs would exceed initial estimates, but not by a large margin.

FIGURE 1

ESTIMATED AND ACTUAL CAPITAL COSTS
1966-1976

(Data missing on estimated costs for 1974)



▲ = Initial Cost Δ = Interim Estimate on all Prior Plants O = Final Report

Table 4

AVERAGE ESTIMATED FINAL COST, $/kw, AT SELECTED POINTS IN TIME, FOR NUCLEAR UNITS UNDER CONSTRUCTION, 1965-1975

NSSS			Average Estimated Final Cost $/kw as of:						
Order Date	1/67	1/68	1/69	3/70	1/71	1/72	1/73	1/75	4/76
1965-Turnkey	137	133	131	129	143	155	226	-	-
Other	123	138	148	170	215	257	279	694	-
1966-Turnkey	126	125	126	117	131	129	157	-	-
Other	122	129	141	160	188	213	277	328	429
1967	-	148	148	171	194	237	319	448	539
1968	-	-	156	193	206	252	359	460	578
1969	-	-	-	208	228	328	375	571	701
1970	-	-	-	-	217	248	301	402	501
1971	-	-	-	-	-	301	370	521	591
1972	-	-	-	-	-	-	420	541	722
1973	-	-	-	-	-	-	-	583	678
1974	-	-	-	-	-	-	-	549	690
1975	-	-	-	-	-	-	-	-	694

Source: Central Station Nuclear Plants, AEC and ERDA, selected issues, 1967-1976

Estimates of the cost of newly ordered plants did increase from year to year between 1968 and 1971, rising from about $150 per kilowatt in 1968 to $220 per kilowatt in 1971. They rose more rapidly than interim estimates of the cost of plants under construction, but perhaps no more than sufficiently to incorporate the additional inflation that would affect plants with later completion dates.

Licensing Delays

Between 1967 and 1970, problems in licensing and constructing nuclear plants began to surface. With a total of 50 new commitments to deal with during 1966 and 1967, the AEC's capacity to process applications showed signs of strain.

By the fall of 1967 licensing delays were apparent throughout the industry and, by the end of 1967, 26 plants were caught in the construction permit process alone. Table 5 reveals that the time required to obtain a construction permit for a reactor ordered in 1968 was 14 months longer, on average, than it had been for a reactor ordered in 1966. Between 1966 and 1970, the situation worsened as the time required to obtain a construction permit (CP) increased by another 15 months. The actual distribution of time to obtain CPs is detailed in Table 6.

During the 1966-1970 period, intervenors such as environmental groups, states, and municipalities, entered the licensing process. There were a few well publicized cases in which the activities of intervenors resulted in lengthening of the licensing process.

TABLE 5

1966 CP Application

7/66	CP application	
7/67	CP issuance	12 months
7/69	OL application	24 months
5/73	OL issuance	46 months
9/73	commercial status	4 months
		86 months

(Average time, CP application to commercial, 7 years, 2 months.)

1968 CP Application

			Change from 1966 (Months)
7/68	CP application		
9/70	CP issuance	26 months	+14
3/73	OL application	30 months	+ 6
?/77	OL issuance		
?/77	commercial status		

(Average time, CP application to commercial, over 8 years.)

1970 CP Application

			Change From 1966 (Months)	Change From 1968 (Months)
7/70	CP application			
12/73	CP issuance	41 months	+29	+15
1/76	OL application	36 months	+12	+ 6
?/79	OL issuance			
?/79	commercial status			

(Average time, CP application to commercial, over 9 years.)

Source: Status of Central Station Nuclear Power Reactors, Significant Milestones, ERDA-30, July 1976.

TABLE 6
REGULATORY TIME LAGS - NUCLEAR LICENSING

I. Construction Permit Phase

Applied for CP in year:	No. of units	No. with CP by 9/76	Time to obtain CP (months)							
			Average	Range	0-10	11-20	21-30	31-40	41-50	Other
1963	2	2	10.5	8-13	1	1				
1964	2	2	10.5	9-12	1	1				
1965	4	4	7.5	5-10	4					
1966	16	16	11.9	6-23	8	6	2			
1967	26	26	13.5	7-28	2	23	1			
1968	13	13	27.2	16-59		9	1		2	1 (59)
1969	11	11	23.5	8-41	1	5	2	2	1	
1970	17	16*	38.4	27-52			4	4	6	2 (52)
1971	12	8	37.5 e			3	1	4		4 no CP (60+)
1972	6	6	29.3	18-45		1	3		2	
1973	29	18	25.5 e			9	7	2		9 no CP (39+)
1974	42	7	26.2 e			2	5			35 no CP (27+)
1975	8	-								

* One cancellation.

e refers to the minimum possible average for that year; i.e., by assuming that plants not obtaining CP by 9/76 actually obtain CP in 10/76.

TABLE 6
REGULATORY TIME LAGS - NUCLEAR LICENSING

II. Primary Construction Phase - CP to Application for Operating License

Obtained CP in year:	No. of units	No. applying for OL by 9/76	Time CP to OL Application (months)							
			Average	Range	0-10	11-20	21-30	31-40	41-50	Other
1963	1	1	29.0	29			1			
1964	3	3	23.7	20-26		1	2			
1965	1	1	22.0	22			1			
1966	5	5	20.4	13-24		1	4			
1967	14	14	24.1	13-40		8	3	3		
1968	24	24	26.3	8-66	2	5	9	7		1 (66)
1969	7	7	22.3	4-30	1	1	5			
1970	10	10	30.2	13-44		2	2	4	2	
1971	4	1	56.3 e				1			3 no OL App (67+)
1972	8	6	28.8 e			3		3		2 no OL App (45+)
1973	14	3	33.1 e			2		1		11 no OL App (42+)
1974	21	-								
1975	9	-								

e refers to the minimum possible average for that year; i.e., by assuming that plants not applying for OL by 9/76 actually apply in 10/76.

TABLE 6

REGULATORY TIME LAGS - NUCLEAR LICENSING

III. Operating License Phase

Applied for OL in year:	No. of units	No. with OL by 9/76	Time to obtain OL (months)							
			Average	Range	0-10	11-20	21-30	31-40	41-50	Other
1963	-	-	-	-						
1964	1	1	23.0	23			1			
1965	2	2	19.5	16-23		1	1			
1966	1	1	11.0	11		1				
1967	4	4	29.0	25-38			3	1		
1968	8	8	21.1	20-42		3	1	3	1	
1969	10	10	41.5	18-61		1		3	4	1 (52) 1 (61)
1970	15	15	40.1	24-69		1	4	4	4	1 (60) 1 (69)
1971	15	12	45.5 e				2	5	3	1 (60) 3 no OL 1 (67) (65+)
1972	4	3	32.3 e				2	1		1 no OL (47+)
1973	5	2	-					2		
1974	5	-	-							
1975	3	-	-							

e refers to the minimum possible average for that year; i.e., by assuming that plants not obtaining OL by 9/76 actually obtain OL in 10/76.

TABLE 6
REGULATROY TIME LAGS - NUCLEAR LICENSING

IV. Operating License to Commercial Operation

Obtained OL in year:	No. of units	No. commercial by 9/76	Time - OL to commercial operation (months)							
			Average	Range	0-10	11-20	21-30	31-40	41-50	Other
1963	1	1	2.0	2.0	1					
1964	2	2	0	0	2					
1965	-	-	-	-	-					
1966	1	1	17.0	17		1				
1967	3	3	19.7	7-42	2				1	
1968	-	-	-	-						
1969	4	4	7.5	4-10	4					
1970	3	3	5.7	4-8	3					
1971	6	5	20.2 e		2	2	1			1 no com'l (58+)
1972	4	4	6.0	0-9	4					
1973	12	12	2.3	0-13	11	1				
1974	15	14	2.3 e		14					1 no com'l (29+)
1975	3	3	.6	0-2	3					

e refers to the minimum possible average for that year; i.e., by assuming that plants not commercial by 9/76 actually go commercial in 10/76.

Source: Status of Central Station Nuclear Reactors - Significant Milestones, ERDA, September 1976.

However, there is clear evidence that a major part of the increase in regulatory delay was due to bottleneck problems involving the staff and the Advisory Commission on Reactor Safety (ACRS). In 1966, uncontested applications could be processed in ten months or less; by 1970, it took a year and one-half or more simply to perform the staff and ACRS review preceding announcement of establishment of a licensing board and scheduling of prehearing conferences. This increase, it might be noted, occurred before the expansion of the scope of the CP review process to handle antitrust and environmental matters. No doubt a part of this bottleneck problem was indirectly related to intervention; it simply takes more staff time to prepare answers to issues that might be raised by intervenors in a contested hearing than would be the case in an uncontested hearing.

Delays in Construction

Licensing requirements were not, however, the only source of delay or of increasing costs. The Joint Committee on Atomic Energy warned in 1967 that manufacturers might have problems in delivering equipment on time and in meeting performance and safety standards. To keep up with nuclear demands, in October 1968, General Electric announced major expansion of two manufacturing divisions (Electrical World, October 28, 1968). Another NSSS manufacturer, Babcock and Wilcox, was reported to have problems in meeting delivery dates because of lack of capacity.

One contemporary study found the following reasons for delays in bringing nuclear units on line:

1.	Labor Trouble	28 plants
2.	Licensing Delays	25 plants
3.	Late Delivery of Pressure Vessels	21 plants
4.	Public Opposition	16 plants
5.	Construction Problems	16 plants
6.	Scheduling Problems	6 plants

(Source: Electrical World, March 2, 1970).

Labor trouble, late delivery, construction and scheduling problems can all be interpreted as evidence of bottlenecks resulting from rapid expansion of damand for nuclear plants. Contemporary authorities recognized that equipment problems were epidemic, but favored the bottleneck hypothesis. The president of Westinghouse Power Systems, for example claimed that "much of the delay being experienced by some utilities is simply the result of the large influx of orders experienced in 1966-1967. Once this is behind us, plants should consistently come on line with five year lead time from order to operation." (Electrical World, September 1, 1970)

The Relation Between Estimated and Actual Costs: 1966-1970

Although licensing and construction delays were recognized in the nuclear industry, their full implications for nuclear costs did not appear in cost estimates by utilities until after 1970. Between 1968 and 1971, estimates of nuclear capital costs were formed by utilities on the basis of historical experience: inflation and rising interest rates which appeared late in the sixties were not anticipated, delays were seen as largely a transitory phenomenon resulting from the great influx of orders in 1966 and 1967, and increasing the size of nuclear power units was expected to provide the economies of scale that had in the past been obtained by building larger fossil plants. It was not until 1972 and later that cost estimates begin to skyrocket in response to the observed fact that the 50 percent increase in estimates between 1966 and 1970 fell far short of the trend in realized costs.

The first published estimates of capital costs by the AEC was commissioned in March 1968, to be based on March 1967 data (WASH-1082). The study estimated that a 1000 MW plant would cost about $135/kw, a figure lower than 1968 estimates by electric utilities. The procedures used were seriously flawed -- the bill of materials was underestimated, the design of the plant was poorly defined, an unrealistically low interest rate was used, and zero inflation was assumed.

In a second part, published in June 1969 (WASH-1150), an attempt was made to determine the causes of the obvious increase in estimated cost. The WASH-1150 estimate of $250 per kilowatt actually exceeded contemporary utility estimates. The reasons cited for cost increases were:

1. Higher direct costs, due to a revised description of the plant -- including additional safety systems -- and higher prices of factor inputs.

2. Higher indirect costs (which included some construction costs), contingency reserves, and interest rates.

3. Escalation of construction and manufacturing labor rates.

In January 1971 a new estimate of $350/kw was reported (WASH-1230). The increase was attributed to "latest safety requirements, codes, and standards . . ., environmental protection and licensing criteria." WASH-1230 also assumed an additional year of construction time and a higher interest rate. Utility estimates of nuclear costs lagged behind WASH-1230; the average reported for plants under construction in 1971 was only $300/kw.

In Table 7 original estimates and actual realized costs of plants ordered in each year from 1965 to 1970 are compared. As Bupp (1974) has pointed out, not all of these plants have yet been completed, and estimates of costs for plants still in the operating license process when the data were assembled exceed the actual cost of completed plants.

The 1965 and 1966 cohorts were completed at an average cost twice the estimate. Costs of completed plants in the 1967 and 1968 cohorts range from two and one-half to three times the initial estimate, but it must be emphasized that these retrospective comparisons could not be made by utilities considering nuclear power plants in 1970 or 1971. They had only the historical experience of the utility industry with construction of fossil fueled power plants and four years of nuclear construction experience to rely on. Moreover, plants such as Connecticut Yankee and San Onofre had been completed on time and, to all appearances, under budget.

TABLE 7

COMPARISON OF AVERAGE INITIAL ESTIMATES TO ESTIMATED AVERAGE ACTUAL COSTS OF NUCLEAR PLANTS BY YEAR OF ORDER

Year of NSSS Order	Average Initial Estimate	Estimated Average Cost of Plants Completed by 1/77
1965	120	240
1966	125	240
1967	150	365
1968	155	460
1969	205	
1970	220	

Source: Central Station Nuclear Plants, AEC and ERDA 1968-1976

Estimated Average cost of plants completed by 1/77 uses WASH-1345 estimates of turnkey costs.

A TIME OF CHANGE: 1971-1976

During the seventies initial estimates of the cost of newly ordered plants increased rapidly, from \$200/kw during 1970 to almost \$700/kw during 1975. The fact that information on the actual costs of completed plants became available at almost exactly the time that new estimates shot up (see Figure 1) suggests that utilities were learning from experience. From 1971 on, year to year changes in updated estimates of the eventual costs of plants under construction increased at about the same pace as initial estimates.

But the actual costs of completed plants also increased rapidly during the seventies. During 1970 and 1971 many of the turnkey plants ordered before 1967 were completed; average reported costs in those years were about \$125/kw. Through 1974 reported costs increased at an average of \$50 per year. Plants completed in 1975 and early 1976 provided the real shock; the average cost of plants completed during 1975 was \$425 per kilowatt, compared to \$300 per kilowatt during 1974. And plants completed during 1976 cost on average \$560 per kilowatt.

These changes in real -- as opposed to estimated -- costs resulted from changes in the regulatory process and from external events which changed the whole environment in which utilities operated.

The Regulatory Process

Events in the regulatory process tend to increase capital costs in two general ways. First, regulation can increase costs through mandated changes in the design and construction of plants when regulatory guidelines are strenghtened or extended; such added costs reflect the substantive impact of regulation. Second, regulation can increase costs by imposing delays on the construction process, even when no changes take place in the design or construction of the plant; such costs represent the procedural effects of regulation. The most important procedural effects arise from changes in the length of time required to complete the licensing process. As that time increases, interest payments on prior expenditures accumulate and inflation drives up the cost of later procurements.

Table 4 revealed that the length of time spent in construction permit processes alone was 29 months longer for a plant ordered in 1970 than for one ordered in 1966. The primary reason for licensing and construction delays from 1970 on was undoubtedly increasing attention to environmental and safety issues, much of which stemmed from intervenor activities in the licensing process.

The Calvert Cliffs decision introduced a new dimension of environmental concern into licensing procedures. In 1971 the United States District Court ruled that the National Environmental Policy Act of 1969 required the AEC to consider all environmental impacts of a nuclear plant in deciding to issue a construction permit or operating license. During 1971 the AEC began to implement this ruling, which required preparation of new environmental impact statements for all plants not yet in operation. By October 1972, Electrical World estimated that 48 plants had suffered construction delays since the effects of Calvert Cliffs on schedules had become apparent.

Throughout the seventies the AEC issued increasingly stringent standards regulating environmental impacts and safety of nuclear plants under construction; additional delays resulted from AEC rulings which applied new standards to all nuclear plants. On June 15, 1971, Electrical World reported that five plants would be delayed in construction because of a new study of the Emergency Core Cooling System that would result in imposition of new requirements, adding $4 million to the cost of a typical reactor. Another example of a substantive effect of nuclear regulation is the estimated increase of $12 million in costs per plant for water intake structures, noise abatement measures, etc. mandated by the AEC in the 1971-1973 period.

It should be noted that there is some evidence (Indian Point 2, Surry 1, Electrical World, May 1, 1972; September 15, 1972) that delays and costs of rebuilding nuclear plants were due to inadequate initial design, as well as to the regulatory requirements.

During 1973 the AEC admitted that ". . . increases in reported power plants costs [have] continued to exceed expectations. Essentially all power plants under construction . . . show large costs overruns . . ." The AEC identified the causes of cost overruns as:

1. Additional engineering. safety and environmental factors.
2. Increased costs, of all types
3. Increased escalation and interest due to longer project time.

Responses to Changing Circumstances

During the early seventies utilities became aware of the serious underestimation of costs in early expectations about nuclear power.

From 1971 on, the year-to-year increase in cost estimates for new plants ranged from $75 to $150 per kilowatt. The average of reported costs showed a smaller annual increase, of $50 per kilowatt, until 1975. Interim estimates of costs of plants under construction increased at about the same pace as initial estimates (see Table 5 and Figure 1).

Estimates of cost of plants ordered during 1975 reached an average of $700 per kilowatt -- a figure which will still be low unless there is a sizable fall in historical escalation rates.

Despite the rising estimates of nuclear costs, orders for nuclear plants rose from 1970 until 1973, and then fell off precipitously as indicated in Table 1. As early as 1972 some cancellations and deferrals were, however, reported. Two factors can be identified as explanations for the surge of nuclear orders in the early 70s. First, air quality regulations made construction of fossil fueled plants appear expensive, infeasible, or at least, antisocial, in many areas of the country. Second, during the 70s coal-fired power plants -- the most attractive alternative to nuclear power given the limitation on oil and gas supplies that devloped after 1970 -- were also increasing in costs, and coal fuel prices were rising as well.

Table 8 presents data on coal and nuclear capital costs between 1968 and 1976 (1974 for coal). New nonturnkey nuclear units coming on line in 1972 had capital costs that were 70 percent higher than those for new coal units, with the differential reduced to roughly 50 percent higher in 1973-1974. While nuclear capital costs for units coming on line show a high rate of escalation (between 25 and 30 percent per year over the past few years), there has also been a marked rate of escalation in coal capital costs as well. As noted earlier, due to the long and variable gestation period for nuclear units, data on units coming on line tend to understate the average capital costs for any cohort of plants, so that as dramatic as are the cost changes shown, in fact capital costs were escalating even more rapidly than indicated. Offsetting this was the increase in capital costs for coal, coupled with technological and cost uncertainties as to the new environmental controls (scrubbers, cooling towers, etc.) that were beginning to be applied to coal units.

Moreover, after remaining almost constant for many years, coal fuel prices began to rise dramatically during the late sixties. At first the rise in prices was driven by increasing labor costs in coal-mining which resulted from new standards protecting miners' health and safety. The rise in coal prices played an important role in continued viability of nuclear power through 1973. Then a strike reduced mine output during 1973 at the same time that rising oil prices led some utilities to increase their demand for coal. A 300 percent increase in spot prices during 1974 resulted; many

TABLE 8

HISTORICAL CAPITAL COST DATA, 1968-1976
NUCLEAR AND COAL POWER PLANTS

Year	Number of Units Coming on Line			Average MWe per Unit Coming on Line			Capital Cost $/KW			Range Capital Cost $/KW		
	Nuclear Non-Turn	Nuclear Turn	Coal	Nucl Non-T	Nucl Turn	Coal	Nucl Non-T	Nucl Turn	Coal	Nucl Non-T	Nucl Turn	Coal
1968	--	2(N)	9(N) 17(A)	---	525(N)	344(N) 360(A)	---	164(N)	117(N) 132(A)	----	153- 180	72- 184
1969	1(N)	1(N)	13(N) 17(A)	620(N)	550(N)	382(N) 486(A)	262(N)	163(N)	140(N) 114(A)	262	163	79- 192
1970	--	2(N) 1(A)	13(N) 10(A)	---	520(N) 810(A)	488(N) 472(A)	---	151(N) 114(A)	157(N) 113(A)	----	114- 161	83- 205
1971	1(N)	2(N) 2(A)	11(N) 11(A)	812(N)	615(N) 785(A)	693(N) 507(A)	181(N)	170(N) 115(A)	128(N) 120(A)	181	101- 185	96- 216
1972	4(N) 1(A)	1(N) 2(A)	7(N) 14(A)	712(N) 760(A)	879(N) 701(A)	665(N) 556(A)	274(N) 143(A)	121(N) 129(A)	174(N) 160(A)	143- 353	121- 136	115- 244
1973	4(N) 3(A)	-	8(N) 14(A)	765(N) 873(A)	---	562(N) 652(A)	293(N) 184(A)	---	204(N) 157(A)	161- 393	---	115- 307
1974	4(N) 5(A)	-	10(N) 10(A)	811(N) 914(A)	---	565(N) 693(A)	347(N) 320(A)	---	230(N) 172(A)	191 546	---	136- 312
1975	7(N) 3(A)	-	NA	875(N) 905(A)	---	NA	436(N) 408(A)	---	NA	251- 518	---	NA
1976	3(N)	-	NA	914(N)	----	NA	560(N)	---	NA	415- 692	---	NA

Number of units coming on line, coal, is the number of new coal units reported in Steam Electric Plant Construction Cost and Annual Production Expenses, FPC, 1968-1974. Nuclear units, non-turnkey and turnkey are from Central Station Nuclear Plants, AEC and ERDA, 1968-1976.

(N) and (A) in the units coming on line columns refer to new plants and additions to existing plants respectively.

Capital Cost $/KW, for coal, are FPC figures, 1968-1974; nuclear data are from FPC, 1968-1974, and from Central Station Nuclear Plants, 1975, 1976.

utilities were cut off from coal promised under long-term contracts as suppliers diverted coal to the more profitable spot market. The importance of the oil embargo and resulting increases in all fuel prices goes without saying, of course.

By 1975 coal prices had stabilized at a level about twice that reached in the mid-60s. Coal remained about one-half the price (per million BTU's heating value) of oil, and supplies were adequate to meet utility demand.

On net balance, developments through the early 70s apparently favored expansion of nuclear capacity for baseload plants. But as early as 1972, there were indications that the rate of escalation of nuclear capital costs was beginning to tip the scales in favor of coal.

In 1972, several utilities cited nuclear cost increases and construction delays as reasons for reversing earlier decisions and choosing coal over nuclear (Florida P & L, Iowa P & L). During 1972 three nuclear units were canceled, one in favor of a coal fueled facility. During 1973 another reason for cancellations and deferrals became apparent -- rising costs and inadequate revenues were making utilities unable or unwilling to finance capacity expansion. On March 1, 1973, Georgia P & L announced deferral of two nuclear units because of financial strains resulting from denial of a request for a rate increase. Seven outright cancellations reported in 1973 were attributed, at least in part, to environmental opposition.

In 1974 still a third reason for cancellations and deferrals became apparent -- the unprecedented slowdown in electricity demand growth that resulted from rising energy prices, recession, and mild weather. Electrical World (September 15, 1974) stated that throughout the industry, "Rescheduling of generating additions approaches landslide proportions as U.S. utilities move to align capital expenditures with lower than expected load growth." Generating capacity was projected to grow faster than load through 1976 despite announced cutbacks.

Because of their high capital cost and long lead times, nuclear plants were particularly vulnerable to financing problems and cutbacks due to inadequate demand. Electrical World (October 15, 1974) estimated that 36 percent of all nuclear units under construction had their schedules set back during 1974. A few were reported to be plants suffering construction delays, but most were reported to be victims of "utility ordered stretchouts averaging two years."

As utility financial problems eased during late 1975 and 1976, general construction plans recovered, but coal orders remained low while nuclear cancellations exceeded new orders. It is difficult to say whether this represents a temporary legacy of low demand and financial difficulties of 1974 and 1975, or a permanent shift away from nuclear power.

CAUSES FOR NUCLEAR CAPITAL COST INCREASES, 1966-1976

It might be well to place the cost history of nuclear power reactors in perspective through comparisons with other indicators for the 1967-1976 period. Table 9 shows that the GNP

TABLE 9

PRICE INDICES AND INTEREST RATES, 1967-1976

Year	GNP Price Index (1972 = 100) Index	GNP Price Index (1972 = 100) % Change	Construction Price Index (1967 = 100) Index	Construction Price Index (1967 = 100) % Change	Net Yield Moody's Aaa Corp. Bonds	% Change in KWe Cost of Nuclear Units Coming on Line
1967	79.0	+2.9	100.0	+1.2	5.51	-
1968	82.6	+4.5	104.9	+4.9	6.18	-
1969	86.7	+5.0	110.8	+5.9	7.03	n.a.
1970	91.4	+5.4	112.6	+1.7	8.04	n.a.
1971	96.0	+5.1	119.7	+6.3	7.39	n.a.
1972	100.0	+4.1	126.2	+5.4	7.21	n.a.
1973	105.8	+5.8	136.7	+8.4	7.44	+ 6.0
1974	116.4	+10.0	161.6	+18.2	8.57	+44.2
1975	127.3	+9.3	176.4	+9.2	8.83	+30.1
1976	133.8	+5.1	187.9	+6.5	8.43	+30.9
1967-1976		+69.4	1967-1976	+87.9		
1972-1976		+33.8	1972-1976	+48.9	1972-1976	+136.3

Source: GNP price index, construction price index, and yields from the Economic Report of the President, January 1977; change in cost of nuclear units is taken from Table 8, except that data for the turnkey years (1968-1971) is excluded, and the 1972 average cost ($/kw) excludes the two turnkey units completed in 1972.

implicit price index increased by 69 percent between 1967 and 1976, and the construction price index increased by 88 percent. Capital cost per kw for nuclear units coming on line rose by 136 percent between 1972 and 1976 alone; data for the early years are suppressed due to the known problems with turnkey reported costs. Between 1967 and 1976, the interest rate on AAA bonds rose from 5.51 percent to 8.43 percent, an increase of roughly 53 percent.

If construction costs for nuclear units had risen at the average rate for the construction industry as a whole, and if interest costs (roughly 17 percent of total costs for a nuclear unit, according to WASH-1345, but now near 30 percent of total costs due to lengthened completion times) had risen simply to reflect the increase in interest rates, then the cost of a nuclear unit would have roughly doubled between 1967 and 1976 and would have risen by perhaps 60 percent between 1972 and 1976 rather than the 136 percent increase indicated by the last column of Table 9. The difference is accounted for by several factors:

1. Nuclear units being built in the 1970s were different from those being built in the 1960s, because of new safety and environmental requirements.

2. The time required to complete the licensing-construction process for new units coming on line increased from five years in 1967 to nine years in 1976, and will be even longer for units still in the pipeline.

3. Rising interest rates interacted with delays to increase interest charges.

4. Because of bottleneck problems, labor and material cost increased much more in nuclear construction than in construction in general.

5. Licensing costs rose substantially over the period.

The leading study that has addressed itself to analyzing the relative importance of these factors is the study by Bupp[7]. Bupp's work has been complemented by studies undertaken by the AEC, and by the utility industry and contractors.

Bupp finds that one driving factor in cost increases was the increase between 1965 and 1975 in manpower and raw material requirements of nuclear power plants.[8] Bupp interprets this increase to be "obviously a consequence of more stringent nuclear safety and environmental design criteria," but asserts that the increase in reactor construction time is thought to be more important.

Bupp divides total project length into licensing time -- the time between application for and issuance of the construction permit -- and on-site construction time -- the interval between beginning of site preparation and operation of the reactor. He finds that "an increase in the licensing time has a strong effect on total costs" but that the relationship between total costs and on-site construction time is insignificant.

Bupp gives two reasons why increases in the licensing period might increase total costs: (1) the length of the licensing period measures the stringency of design changes and safety features that are required; (2) long licensing periods lead the utility to speed construction to make up for licensing delays, with consequent increases in costs. Bupp observes that this may also explain the lack of correlation between on-site construction time and costs.

In summary, Bupp identifies the major factor behind the differential rate of increase in nuclear costs to be the activities of intervenors; he concludes that the nuclear licensing process has been used by opponents of nuclear power as a vehicle for raising the private cost of nuclear power to the perceived level of social cost.

WASH-1345,[9] published by the AEC in October 1974, represents an alternative approach to the nuclear cost issue. Rather than attempting to identify underlying causal factors, WASH-1345 undertook a retrospective study of cost increases between 1966 and 1974 by estimating costs, by categories, for nuclear units coming on line during those periods. Escalation of labor and material costs and increases in interest during construction were identified as the major components of cost increase between 1966 and 1974. In addition, the study found that direct construction costs more than doubled over the period, with about $90 million in cost of a hypothetical 1000 MW plant ordered in 1973 ($90/kw) being due to environment and safety related changes in plant design mandated between 1971 and 1973.

Because the approaches are different, there is no necessary conflict between these conclusions; and because nuclear units are so site specific in characteristics and so lacking in standardization, neither study can be said to represent a definitive answer to the question of the source of cost increases between 1966 and 1974. That licensing problems represent a major source of cost increases from 1970 on is clearly correct, and that bottleneck problems have been present throughout the history of the industry is also true. But the conclusion of Bupp's study that intervenors are to be assigned the major role in the explanation of cost increases deserves further comment.

Intervention in the licensing process became the normal pattern from 1969 on; prior to that time, uncontested licensing hearings were as common as hearings in which intervenors appear. Table 10 gives data on construction permit applications between 1966 and 1970.

The average time required to complete the CP process rose from 10.5 months in 1966 to 37.7 months in 1970, and the percent of uncontested hearings drops noticeably between those dates. But the average time required for an uncontested hearing rose from 8.7 months in 1966 to 28.3 months for plants applying for a CP in 1970, which strongly suggests that intervention was not the only factor at work in lengthening the licensing time. Contested hearings, on average, required more time than did uncontested hearings; intervention is associated with time delays. But bottlenecks in the licensing process and changes in

TABLE 10

CP APPLICATIONS
1966-1970

	CP Applications		Uncontested		Contested	
	No.	Avg. Time (Months)	No.	Avg. Time (Months)	No.	Avg. Time (Months)
1966	13	10.5	7	8.7	6	13.8
1967	21	13.2	10	13.7	11	13.0
1968	9	22.8	5	16.0	4	31.3
1969	9	26.5	1	41.0	8	25.0
1970	12	37.7	3	28.3	9	40.8

Source: <u>Status of Central Station Nuclear Power Reactors, Significant Milestones</u>, ERDA-30, July 1976.

rules and regulations unrelated to intervention also clearly played a role in regulatory delays, especially prior to 1971.

It is instructive to look at the case histories of the units applying for CPs during this period, in an attempt to identify the causes of this increase in regulatory delays. Appendix B presents a capsule history of the CP licensing process for each unit entering CP licensing during the 1966-1970 period. It is arranged so that in each year, the units are ranked in terms of the delays experienced in obtaining a CP. It should first be noted that, in general, it is not easy to pinpoint the source of delay in any specific case. Intervenors can delay issuance of a CP by enlarging the scope of issues to be considered by a licensing board, thus increasing the number and time duration of prehearing conferences and hearings; but often those or related issues are also the subject of some disagreements among the staff, ACRS and the licensing board as well, and might have caused delays even in the absence of intervention. It is important to note that appeals after a CP has been issued, whether appeals to the ASLB or the AEC or to the courts, have no effect on delaying construction unless a stay is granted, a relatively rare occurrence. Thus there are many cases of very active intervention, involving many appeals and many issues, but with relatively short time delays in obtaining a CP.

Some general comments are in order concerning the information presented in Appendix B. First, intervention is essentially never completely successful in the sense that a license is refused by an LB. In fact, there are no cases of this occurring during the 1966-1970 period, and none we are aware of in the history of the AEC-NRC. Second, intervention is rarely successful in the sense of changing the location of a reactor or challenging the safety and/or environmental features associated with construction; but there are a few cases in which licenses are conditioned to take into account issues raised by intervenors. Historically there have been cases, such as Malibu, where the conditions imposed were sufficiently restrictive so that the unit was withdrawn after obtaining a CP subject to such conditions. Thirdly, intervenors have been more successful (if that in fact is their goal) in increasing the costs of constructing a reactor, by imposing time delays and by imposing informational costs on a utility. A striking case of that is Bailly, a unit to be located near Dunes State Park in Indiana, which went through a long and bitter CP hearing, after which various stays have been imposed on construction through court actions.

The primary success of intervenors has been generic rather than specific to individual plants. As indicated in Appendix B, contested hearings in 1966-1968 often involved the issue of "practical value" of nuclear units, with small utilities and municipalities attempting to intervene to force antitrust hearings. This led to Congressional action in 1970 mandating an antitrust review of all units entering the nuclear licensing process. Similarly, environmental issues raised in the later 1960s led finally to the incorporation of an environmental review as a part of the CP issuing process. No doubt antitrust review and environmental review can, in certain cases at least, provide substantive relief to complaints of intervenors. But these reviews also increase the overall time delays associated with licensing and hence the cost of reactors, so that they also play a role in decreasing the economic advantages of nuclear power.

The history of the 1966-1970 period was not simply one of intervenors entering the licensing process and automatically imposing delays on plant licensing. But after 1970 the success of intervenors on generic issues led to substantial cost increases to meet new design and safety requirements. Moreover, Calvert Cliffs led to major time delays in preparing environmental impact statements and in hearings on such statements.

OPERATING COSTS OF NUCLEAR AND COAL UNITS

Finally, some comments should be made about the total costs of generating electricity using nuclear units as compared to coal units. Cost-benefit analyses of nuclear units have typically assumed an 80 percent plant factor (output/capacity) for these base load plants, and the AEC has historically employed comparably high plant factors in its comparisons of costs between coal and nuclear. The higher is the plant factor, the lower are capital costs per unit of output, so that high plant factors lead to a more favorable cost comparison for nuclear units relative to coal.

As early as the mid-60s, some utility managers were expressing skepticism concerning the assumption that nuclear units could operate in the 80 percent range.

A recent study found that capacity factors deteriorated with the increasing scale of new plants, as a result of equipment malfunctions and difficulty in effecting repairs.[10] The deterioration was found to be so rapid that capital costs per kilowatt-hour generated actually increase with increasing scale above about 800 MWe. Komanoff also found that coal plants had somewhat better performance than nuclear plants when an optimum size coal plant is compared to a nuclear plant of optimum size (optimum being defined as the size at which capital costs per kilowatt-hour are minimized, with the reduced cost due to scale economies in construction being just balanced by the increased cost due to poorer operating performance).

Komanoff's conclusions are based on a relatively small data base and are disputed by utility spokesmen and reactor manufacturers, who argue that the shakedown period for large reactors has not yet been completed in the reactors currently operating, and that higher plant factors and lower costs will be observed in future years.

FPC data on nuclear and coal units coming on line between 1968 and 1973 (presented in Table 11) indicate that while nuclear units have not met the 80 percent plant factor goal, nonetheless operating costs and total costs (including capital cost) per unit of output were less on average for nuclear than coal.

Coal units coming on line in 1968 operated at a plant factor of roughly 55 percent between 1969 and 1974, while nuclear units of the same vintage had an average plant factor of roughly

TABLE 11
HISTORICAL OPERATING COST COMPARISON, 1968-1973
NUCLEAR AND COAL POWER PLANTS

New Coal Units Coming On Line In						
Year	1968	1969	1970	1971	1972	1973
Non-Fuel Cost (Mills/kwh)						
1969	.61	---------	---------	---------	---------	---------
1970	.55	.56	---------	---------	---------	---------
1971	.71	1.01	.67	---------	---------	---------
1972	.61	.79	.60	1.15	---------	---------
1973	.94	.99	.76	1.03	.93	1.75
Fuel Cost (Mills/kwh)						
1969	2.65	---------	---------	---------	---------	
1970	2.85	2.56	---------	---------	---------	
1971	2.98	2.99	2.83	---------	---------	
1972	3.26	3.31	3.16	3.20	---------	
1973	3.55	3.68	3.56	2.97	3.63	4.00
Total Operating Cost (Mills/kwh)						
1969	3.26	---------	---------	---------	---------	---------
1970	3.40	3.12	---------	---------	---------	---------
1971	3.69	4.00	3.50	---------	---------	---------
1972	3.87	4.10	3.76	4.35	---------	---------
1973	4.49	4.67	4.32	4.00	4.56	5.75
Plant Factor: Output/Capacity Percent						
1969	56	---------	---------	---------	---------	---------
1970	61	47	---------	---------	---------	---------
1971	55	58	65	---------	---------	---------
1972	62	59	67	42	---------	---------
1973	60	59	62	58	48	---------
Total Output (Million kwh)						
1969	6137	---------	---------	---------	---------	---------
1970	6772	13766	---------	---------	---------	---------
1971	6267	19873	9302	---------	---------	---------
1972	6861	23810	12435	19670	1369	---------
1973	6825	23229	11349	30660	4160	2661
Range-Total Operating Cost (Mills/kwh)						
1969	2.36-4.95	---------	---------	---------	---------	---------
1970	2.40-5.26	2.37-3.65	---------	---------	---------	---------
1971	2.46-5.72	2.68-6.99	2.06-4.98	---------	---------	---------
1972	2.55-6.98	3.15-6.00	2.10-4.77	3.10-5.66	4.45-4.55	---------
1973	2.64-7.69	3.57-6.79	2.09-6.12	2.11-6.60	4.45-4.65	3.04-9.32
No. of Units	5	6	5	5	2	4

New Nuclear Units Coming On Line In						
Year	1968	1969	1970	1971	1972	1973
Non-Fuel Cost (Mills/kwh)						
1969	.64	---------	---------	---------	---------	---------
1970	1.02	.71	---------	---------	---------	---------
1971	.76	.86	1.22	---------	---------	---------
1972	1.02	.98	2.15	.51	---------	---------
1973	2.60	1.53	2.14	1.36	.93	.92
Fuel Cost (Mills/kwh)						
1969	1.72	---------	---------	---------	---------	---------
1970	1.66	2.32	---------	---------	---------	---------
1971	1.70	1.90	1.99	---------	---------	---------
1972	1.64	2.23	2.10	1.98	---------	---------
1973	1.68	2.35	2.57	2.09	1.64	2.59
Total Operating Cost (Mills/kwh)						
1969	2.36	---------	---------	---------	---------	---------
1970	2.68	3.01	---------	---------	---------	---------
1971	2.46	2.76	3.21	---------	---------	---------
1972	2.66	3.21	4.26	2.49	---------	---------
1973	4.28	3.88	4.71	3.45	2.57	3.51
Plant Factor: Output/Capacity Percent						
1969	67	---------	---------	---------	---------	---------
1970	67	59	---------	---------	---------	---------
1971	82	67	61	---------	---------	---------
1972	78	77	54	64	---------	---------
1973	52	68	60	54	65	---------
Total Output (Million kwh)						
1969	6246	---------	---------	---------	---------	---------
1970	6597	5141	---------	---------	---------	---------
1971	7490	6762	6285	---------	---------	---------
1972	7112	7599	5532	10153	---------	---------
1973	4692	7079	5273	9446	11960	7189
Range-Total Operating Cost (Mills/kwh						
1969	2.22-2.61	---------	---------	---------	---------	---------
1970	2.60-2.74	2.77-3.51	---------	---------	---------	---------
1971	2.28-2.70	2.49-3.18	2.78-3.76	---------	---------	---------
1972	2.30-3.23	2.64-3.99	3.98-4.40	2.29-2.99	---------	---------
1973	4.16-4.41	3.37-4.38	3.05-7.60	3.23-3.99	2.24-4.48	2.38-4.10
No. of Units	2	2	2	3	2	3

Source: Steam Electric Plant Construction Cost and Annual Production Expenses, FPC annual issues, 1968-1973.
Data are shown only for new units for which no additions to capacity occurred between time of installation and 1973. Each unit is weighted by its output each year in arriving at average costs and plant factors.

70 percent. In 1974, operating cost/kwh for 1968 vintage coal units was 5.87 mills, while for 1968 nuclear units, cost was 2.74 mills; and for 1969 vintage plants, the costs were 7.02 mills/kwh for coal versus 5.12 mills/kwh for nuclear. A similar operating cost advantage applies for later vintage units.

The basis for the observed cost advantage for nuclear units is low fuel cost, which is not completely offset by higher capital costs for nuclear units than coal units. Using a 16 percent fixed charge rate together with the observed plant factors for coal and nuclear units of 1972 and 1973 vintage, total cost (mills/kwh) in 1974 was 13.43 for 1972 vintage coal units and 12.49 for 1972 nuclear units; total cost in 1974 was 18.42 mills/kwh for 1973 vintage coal units versus 14.56 mills/kwh for 1973 vintage coal units. Thus as of 1974, the most recent year for which FPC coal capital cost data are available, new nuclear units were producing electricity more cheaply than new coal units.[11]

FOOTNOTES

1. The use of average capital cost per kw as an index of the cost of nuclear units suffers from the problem of lack of standardization of such units. It is well known that costs can differ substantially on the basis of region of the country or whether construction labor is union or nonunion for example. Because the number of units coming on line each year is so small, major distortions can be introduced by such factors. For this reason both average cost $/kw and the range of costs are shown in Table 3.

   Also it should be emphasized that costs of units coming on line include dollars of varying purchasing power, since expenditures are spread out over a number of years. Moreover, the rate of increase in costs of nuclear units coming on line underestimates the "true" rate of cost increases, since for any cohort of plants, the cheapest tend to be those that come on line earliest, as pointed out by Bupp (1974).

2. See H. Stuart Burness, W. David Montgomery and James P. Quirk, "The Turnkey Era in Nuclear Power," Social Science Working Paper No. 175, California Institute of Technology, August 1977. Also see "Development and Commercialization of the Light Water Reactor, 1946-1976," Robert Perry, et aL, Rand Corporation, R-2180-NSF, June 1977.

3. There is some confusion in the literature concerning the number and identification of the turnkey plants. Mooz (1976) lists 13 plants built by General Electric and Westinghouse, all contracted for between 1962 and 1966, as turnkey units: Dresden 2, 3, Connecticut Yankee, San Onofre 1, Ginna, Oyster Creek, Millstone 1, Point Beach 1, 2, Robinson 1, Monticello, and Quad Cities 1, 2. ERDA lists an additional 12 units as turnkey, for a total of 25: Big Rock Point, Dresden 1, Yankee Rowe, Humboldt Bay, Peach Bottom 1, Pathfinder, Piqua, Genoa, Fort St. Vrain, Indian Point 2, 3, Northcoast Power. Of these, all except the last four were development reactors built before 1962, and Northcoast Power was later canceled. Further, in WASH-1345, Indian Point 2 is listed as one of 13 turnkey units but Connecticut Yankee is not listed as a turnkey. Generally, we have used Mooz' classification.

4. While GE and Westinghouse ceased to offer fixed price contracts for nuclear units in mid-1966, both continued to offer fixed price contracts for nuclear fuel. Westinghouse's problems with its fuel contracts are well known; General Electric followed a less ambitious program, but for certain units (including Oyster Creek and Browns Ferry) guaranteed fuel price contracts for periods up to 12 years of plant operations were signed. The major difference between General Electric and Westinghouse was that General Electric followed the practice of covering its fuel commitments through forward purchases, while Westinghouse generally remained in an unhedged position.

5. Moreover, in Mooz' discussion of the turnkey era, an executive of Westinghouse is quoted to the effect that San Onofre "came in under budget on time, and made a good profit," while Connecticut Yankee "also returned a modest profit." In contrast, the WASH-1345 estimates show Westinghouse losing $91 million on these two units.

6. This is a highly simplified version of Mooz' view of the turnkey era. The same viewpoint was expressed at the time by Philip Sporn, president of American Electric Power: "Competitive levels of nuclear plants may not be quite so low as initial announcement had seemed to indicate. One of the effects of competition might be to induce a manufacturer to risk somewhat greater uncertainty in the costs behind his turnkey price than might be tolerable repeatedly." (Electrical World, August 17, 1964)

7. Bupp, I., Derian, J., Donsimoni, M., Treitel, R., "Trends in Light Water Reactor Capital Costs in the United States: Causes and Consequences," CPA 74-8, December 1974, Center for Policy Alternatives, Massachusetts Institute of Technology, Cambridge, Massachsuetts.

   For a contrasting view of cost trends, see 1977 Update, Power Plant Economics, H. Brush, Bechtel Power Corporation, January 21, 1976, and Economics of Nuclear Power, W. Davis, Bechtel Power Corporation, January 13, 1975.

8. Bupp estimates that the cost per kilowatt of plants completed before 1975 increased at a rate of $49 per year when the effects of gross geographical and design differences between plants completed in different years are statistically controlled, and $27 when they are not. These estimates cannot be compared directly to Figure 1, because Bupp deflated all costs using the Handy-Whitman index of construction costs. We suspect that such deflation is inappropriate: the Handy-Whitman index is based, in part, on nuclear plant costs. Consequently, some cost changes which need to be explained vanish because of the deflator Bupp uses.

9. Atomic Energy Commission, "Power Plant Capital Costs: Current Trends and Sensitivity to Economic Parameters," WASH-1345, Washington, October 1974.

10. Komanoff, C., Power Plant Performance: Nuclear and Coal Capacity Factors and Economics, Council on Economic Priorities, New York, 1976.

    Komanoff's conclusions are critized on an item by item basis in "The Edison Electric Institute's Comments and Critique of the Council on Economic Priorities Report Power Plant Performance and its later Update," Edison Electric Institute, July 1977.

11. The nuclear units had, however, taken longer to complete. If substitute power were required because of nuclear delays, its cost could have reduced the nuclear advantage. Comparison of nuclear and coal units announced in the same year is impossible because of lack of cohort data on coal.

APPENDIX A

CAPITAL COST DATA FOR NUCLEAR UNITS

The two basic sources of information on capital costs of nuclear units are Steam Electric Plant Construction Cost and Annual Production Expenses, Federal Power Commission; and Central Station Nuclear Plants, AEC/ERDA. The FPC publication appears on an annual basis and covers all steam plants (coal, oil, gas, turbine, nuclear), while Central Station Nuclear Plants appeared monthly (through early 1977), but is limited to nuclear units only. Data on capital costs appearing in the FPC publication are those reported by the utility to the FPC on a standardized basis that applies to all utilities. Data appearing in the AEC/ERDA publications are somewhat more uncertain in origin; most cost estimates are apparently supplied by the utilities, but in certain cases they represent estimates made by AEC/ERDA personnel.

Ideally, time trends in nuclear capital costs would be based on FPC data. Unfortunately, the FPC tends to be quite late in publishing its annual Construction Cost and Production Expenses volume. In fact, the latest to appear as of late 1977 was the volume for 1974. Given the brief history of commercial size nuclear units, using only FPC data would limit the analysis to only five or six years. Moreover when one adds to this that turnkey units dominate the picture through 1971, only three years of reliable cost data would be available for an historical overview, not a particularly happy situation.

We decided to use AEC/ERDA cost figures for 1975 and 1976 in the tables presented in the body of this paper, which permits an extension of time trends up through 1976. We recognize that there might be distortions introduced into the analysis by the use of AEC/ERDA data to supplement the more reliable FPC figures, but there appeared to be no other alternative if any meaningful intertemporal comparisons were to be made. Appendix Table A-1 presents a comparison between FPC data and AEC/ERDA data on a unit by unit basis for each year between 1968 and 1974, the years for which both data sources are available. It will be noted that differences exist for almost all units, either in terms of rated capacity, total capital cost, capital cost per kw, or in terms of the year during which the unit goes on line. Certain of these differences no doubt simply reflect definitional matters (e.g., for the AEC, a unit goes on line when it completes its commercial testing phase, while for the FPC, the date is related to the entrance of the unit to the rate base); while others arise from different reporting sources or the time at which the measurement is taken. It should also be pointed out that in the FPC tables, capital costs continue to increase over time even after a unit has come on line, reflecting various additions made to the unit after it goes commercial; hence there really is no such thing as "the" capital cost of a unit, independent of the time at which the capital cost is calculated. We have used the capital costs as of the year during which a unit goes on line as "the" capital cost of the unit. Moreover, the FPC tables do not give separate data on capital costs of additional units added to an existing unit;

this must be calculated as the change in total capital cost for the plant between the year the new unit comes on line and the previous year. Unfortunately, there is no way to separate out the increase over time in the capital cost of the old unit from the increase in total capital cost due to the new unit. In Table A-1, any cost increase during the year a unit comes on line is assigned to the new unit, and this might account for a part of the difference between the FPC cost figures and those of the AEC/ERDA.

TABLE A-1

CAPITAL COSTS OF NUCLEAR UNITS
COMING ON LINE, 1968-1974
FPC AND AEC/ERDA

PLANT	FPC			AEC/ERDA		
		Capital Cost			Capital Cost	
	MWe	Total (Mill. $)	$/kw	MWe	Total (Mill. $)	$/kw
1968						
T Connecticut Yankee	600	91.8	153	575	95.0	165
T San Onofre	450	80.9	180	430	98.0	228
Average	525		164	503		192
1969						
NT Nine Mile Point	620	162.2	262	610	151.0	247
T Oyster Creek	550	89.9	163	530	83.0	157
Average	585		215	570		205
1970						
T Dresden 2	810	92.3	114	809	94.0	116
T Ginna	517	83.2	161	420	65.0	155
T Millstone	662	96.8	146	652[1]	92.0[1]	141[1]
T Point Beach 1	524	74.0	141	497	61.0	123
Average	628		138	575[1]		127[1]
1971						
T Dresden 3	810	103.8	128	809	100.0	124
T Robinson 2	769	77.8	101	700	76.0	109
T Monticello	569	105.0	185	545	89.0	163
NT Palisades	812	146.7	181	700	118.0	169
Average	740		146	681[1]		139[1]

-CONTINUED-

TABLE A-1

CAPITAL COSTS OF NUCLEAR UNITS
COMING ON LINE, 1968-1974
FPC AND AEC/ERDA

-CONTINUED-

PLANT	FPC			AEC/ERDA		
	MWe	Capital Cost Total (Mill. $)	Capital Cost $/kw	MWe	Capital Cost Total (Mill. $)	Capital Cost $/kw
1972						
T Point Beach 2	524	71.4	136	497	54.0	122
NT Vermont Yankee	514	172.0	335	514	154.0	300
NT Pilgrim	655	231.5	353	644	120.0	186
NT Surry 1	847	146.7	173	788	251.0	319
NT Turkey Point 3	760	108.7	143	693	110.0	159
T Quad Cities 1, 2	1657	200.1	121	1600	250.0	156
Average	708		188	693		217
1973						
NT Surry 2	848	250.2	295	788	149.0	189
NT Turkey Point 4	760	122.5	161	693	106.0	153
NT Zion 1	1089	276.0	251	1050	262.0	249
NT Maine Yankee	830	219.2	264	790[1]	263.0[1]	333[1]
NT Prairie Island 1	593	233.2	393	530	200.0	377
NT Fort Calhoun	481	173.9	361	457	175.0	383
NT Oconee 1	887	155.6	176	886	163.0	184
T/NT Indian Point 2	1013	206.1	203	873	212.0	242
Average	814		251	753		240
1974						
NT Arkansas Nuclear 1	902	233.0	258	850	239.0	281
NT Arnold	566	202.2	357	535[1]	277.0[1]	518[1]
NT Zion 2	1098	289.9	264	1050[1]	271.0[1]	258[1]
NT Prairie Island 2	593	172.2	290	530	200.0	377
NT Cooper	835	246.3	295	778	296.0	380
NT Peach Bottom 2	1152	628.5	546	1065	537.0	504
NT Three Mile Island	871	398.3	457	819	406.0	496
NT Oconee 2	887	320.8	361	871	160.0	184
NT Kewaunee	535	202.2	378	541	201.0	372
NT Peach Bottom 3	[2]	[2]		1065	226.0	212
NT Oconee 3	[2]	[2]		871	166.0	191
Average	827		362	821		329

[1]Millstone is classified as a 1971 unit by AEC, and appears in 1971 averages; Zion 2 and Arnold are classified as 1975 units by AEC; Maine Yankee is classified as a 1972 unit by AEC, and appears in 1972 averages.

[2]Not shown in 1974 FPC.

T = turnkey, NT = nonturnkey.

TABLE A-2

CAPITAL COST ESCALATION -- NUCLEAR PLANTS, 1967-1976
ESTIMATED CAPITAL COST $/KWe AT SELECTED POINTS IN
TIME FOR ALL NUCLEAR PLANTS ORDERED 1965-1975

Units Ordered In:	Status 4/76	1/67	1/68	1/69	3/70	1/71	1/72	1/73	1/75	4/76
		Estimated Capital Cost $/KWe								
1965										
Pilgrim	0-72	100	104	136	192	183	183	183		
Dresden 2 T	0-70	110	98	115	104	116				
Millstone 1 T	0-71	148	159	129	138	141	141			
Indian Pt. 2 T	0-73	121	121	124	121	158	168	226		
Turkey Pt. 3	0-72	97	101	101	107	107	128	159		
Turkey Pt. 4	Can.	87		C A N C E L E D						
Ft. St. Vrain	0-76	209	209	206	212	355	461	494	694	
Robert E. Ginna T	0-70	150	155	155	155	155				
1965 Average		120	126	131	139	159	187	231	694	
1966										
Dresden 3 T	0-71	113	100	113	101	143	125			
Robinson 2 T	0-71	115	115	115	109	109	109			
Palisades	0-71	107	139	127	157	169	169			
Pt. Beach 1 T	0-70	132	134	134	123	123				
Quad Cities 1 T	0-72	126	126	123	109	131	125	188		
Quad Cities 2 T	0-72	112	108	115	101	122	125	125		
Monticello T	0-71	157	157	157	163	163	163			
Browns Ferry 1	0-74	116	110	123	158	140	174	211	227	
Browns Ferry 2	0-75	116	110	123	158	140	174	211	227	251
Oconee 1	0-73	93	103	110	113	127	130	163	184	
Oconee 2	0-74	93	103	110	113	127	131	155	181	
Vermont Yankee	0-72	171	171	171	259	259	300	300		
Salem 1	O/P	126	142	145	133	226	217	367	596	619
Peach Bottom 2	0-74	117	130	153	153	216	270	331	495	
Peach Bottom 3	0-74	117	117	136	136	208	247	297	212	
Surry 1	0-72	125	166	183	212	212	258	309		
Surry 2	0-73	125	138	143	158	158	177	189	189	
Fitzpatrick*	0-75	133	n.a.	135	273	273	272	309	367	367
Fort Calhoun	0-73	156	160	201	262	274	274	[illegible]	383	
Diablo Canyon 1	O/P	142	145	145	145	191	191	302	366	461
Three Mile Island	0-74	131	131	149	195	227	315	443	498	
1966 Average		123	128	137	148	172	192	262	328	429

Units Ordered In:	Status 4/76	1/68	1/69	3/70	1/71	1/72	1/73	1/75	4/76
		Estimated Capital Cost $/KWe							
1967									
Turkey Point 4	0-73	101	101	107	107	139	153	175	
Bailly	C**	177	177	161	244	272	370	690**	693**
Three Mile Island 2	O/P	133	133	133	258	310	510	636	696
Prairie Island 1	0-73	175	175	175	175	245	349	377	
Prairie Island 2	0-74	175	175	175	175	245	349	377	
Kewaunee	0-74	213	213	207	233	227	303	372	
Zion 1	0-73	156	156	195	221	200	229	263	
Zion 2	0-74	146	146	185	203	200	219	258	
Crystal River 3	O/P	137	137	174	174	230	343	455	509
Pt. Beach 2 T	0-72	119	119	109	109	109	109		
Maine Yankee	0-72	166	166	229	229	229	253		
Shoreham	O/P	159	159	266	266	266	377	849	849
Indian Pt. 3	0-76	165	165	162	226	265	328	415	408
Oconee 3	0-74	94	94	94	123	123	155	187	
Cooper	0-74	163	163	163	163	266	266	406	
Calvert Cliffs 1	0-75	156	156	155	155	201	296	404	414
Calvert Cliffs 2	O/P	133	133	131	131	151	241	303	297
Salem 2	O/P	122	122	133	226	213	359	583	605
Bell	Can.	190	190	198	198	198	C A N C E L E D		
Brown Ferry 3	O/P	105	105	122	140	174	211	227	246
D. C. Cook 1	0-75	111	111	111	134	227	201	377	506
D. C. Cook 2	O/P	111	111	111	134	227	201	377	412
Beaver Valley 1	0-76	192	192	223	227	259	399	529	649
Rancho Seco	0-75	168	168	168	167	267	373	367	370
Limerick 1	C	141	141	237	237	378	652	1138	1138
Limerick 2	C	141	141	210	210	296	481	506	506
No. Anna 1	O/P	163	163	247	333	364	401	497	631
Millstone 2	0-75	176	176	216	221	289	341	482	502
Hatch 1	0-75	191	191	192	234	240	359	466	480
St. Lucie 1	0-76	140	140	154	151	254	398	452	593
Nuclear 1	0-74	155	155	155	185	207	226	268	
1967 Average		148	148	171	194	237	319	448	539

T refers to turnkey plant.

TABLE A-2

(Continued)

Units Ordered In:	Status 4/76	1/69	3/70	1/71	1/72	1/73	1/75	4/76
		Estimated Capital Cost $/KWe						
1968								
Verplanck 1	Can.	188	198	273	272	C A N C E L E D		
Brunswick 1	O/P	158	197	197	222	220	328	401
Brunswick 2	O-75	158	197	197	238	256	413	471
Carolina P & L	Can.	158	200	200	C A N C E L E D			
D. Arnold	O-75	196	244	286	279	394	371	518
Sequoyah 1	O/P	143	143	166	189	197	548	317
Sequoyah 2	O/P	143	143	166	189	197	548	317
Susquehanna 1	C	143	143	143	303	571	900	997
Susquehanna 2	C	143	143	143	303	571	573	646
Midland 1	C	253	257	257	278	584	718	1528
Midland 2	C	168	257	257	278	584	718	866
Fermi 2	C	136	197	223	292	391	458	823
Seabrook	Can.	122	216		C A N C E L E D			
Diablo Canyon 2	O/P	150	175	175	175	266	384	384
David Besse	O/P	150	231	231	305	400	479	588
Trojan	O-75	149	179	201	201	251	324	396
1968 Average		156	193	206	252	359	460	578
1969								
Farley 1	O/P		198	245	312	312	550	710
Zimmer 1	O/P		243	262	354	384	536	617
McGuire 1	O/P		169	156	192	187	309	325
McGuire 2	O/P		169	156	192	187	309	325
Forked River 1	C		236	272	428	525	649	649
Hope Creek 1	C		223	264	416	530	n.a.	1172
Hope Creek 2	C		223	264	416	530	n.a.	1172
1969 Average			208	228	328	375	571	701
1970								
Farley 2	O/P			226	281	281	437	575
Nuclear 2	O/P			189	217	250	349	453
Lasalle 1	C			334	300	301	357	417
Lasalle 2	C			278	300	301	357	417
Hatch 2	C			240	240	420	645	645

Units Ordered In:	Status 4/76	1/71	1/72	1/73	1/75	4/76
		Estimated Capital Cost $/KWe				
1970 (Continued)						
Waterford 3	C	197	197	300	400	638
North Coast	Can.	232	240	240	240	CANCELED
San Onofre 2	C	187	187	358	575	1038
San Onofre 3	C	187	187	358	575	849
No. Anna 2	O/P	218	257	232	268	346
Watts Bar 1	C	192	267	277	291	332
Watts Bar 2	C	192	267	277	291	332
Bellefonte 1	C	196	266	296	404	397
Bellefonte 2	C	196	266	296	396	397
1970 Average		217	248	301	402	501
1971						
Harris 1	LWA		255	270	557	1001
Harris 2	LWA		255	270	557	1001
Harris 3	LWA		255	270	557	1001
Harris 4	LWA		255	270	557	1001
Byron Station 1	C		350	348	443	466
Byron Station 2	C		350	321	443	466
Summit 1	Can.		390	442	518	CANCELED
Summit 2	Can.		390	442	518	CANCELED
Beaver Valley 2	C		236	423	804	931
Crystal River 4	Can.		301	C A N C E L E D		
Vogtle 1	C		273	516	567	567
Vogtle 2	C		273	448	488	488
Nine Mile Pt. 2	C		285	343	564	694
GE 1	Post		329	574	574	n.a.
GE 2	Post		329	383	383	n.a.
Fulton 1	Can.		348	351	582	CANCELED
Fulton 2	Can.		348	351	562	CANCELED
Summer	C		258	329	394	394
No. Anna 3	C		291	359	437	720
No. Anna 4	C		291	266	310	466
Hanford 2	C		253	391	510	720
1971 Average			301	370	521	591

TABLE A-2
(Continued)

Units Ordered In:	Status 4/76	1/73	1/75	4/76
		Estimated Capital Cost $/KWe		
1972				
Barton 1	C/P	500	651	1271
Barton 2	C/P	500	576	921
Pilgrim 2	C/P	n.a.	735	735
Perry 1	LWA	409	512	642
Perry 2	LWA	409	512	642
Braidwood 1	C	n.a.	446	479
Braidwood 2	C	n.a.	446	479
Quanicasse 1	Can.	522	C A N C E L E D	
Quanicasse 2	Can.	522	C A N C E L E D	
Fermi 3	Can.	410	605	CANCELED
Greenwood 2	C/P	403	611	611
Greenwood 3	C/P	403	611	611
Catawba 1	C	269	432	470
Catawba 2	C	269	432	470
St. Lucie 2	LWA	320	662	765
River Bend	LWA	638	637	637
Clinch River LMFBR		1748	4960	5571
Grand Gulf 1	C	515	525	560
1972 (Continued)				
Douglas Pt. 1	C/P	398	594	1002
Douglas Pt. 2	C/P	398	594	781
Atlantic Offshore 1	C/P	430	541	1087
Atlantic Offshore 2	C/P	430	541	1087
Seabrook 1	C/P	386	507	507
Seabrook 2	C/P	386	473	473
SCED/HTGR 1	Can.	606	C A N C E L E D	
SCED/HTGR 2	Can.	606	C A N C E L E D	
Hartsville 1	C/P	310	315	488
Hartsville 2	C/P	310	315	488
Hartsville 3	C/P	320	315	488
Hartsville 4	C/P	320	315	483
Camanche Park 1	C	320	309	309
Camanche Park 2	C	320	309	309
Surry 3	C	325	611	1251
Surry 4	C	325	375	891
Nuclear Project 1	C	473	530	942
Grand Gulf 2	C	515	457	560
1972 Average		420	541	722

TABLE A-2
(Continued)

Units Ordered In:	Status 4/76	Estimated Capital Cost $/KWe 1/75	Estimated Capital Cost $/KWe 4/76	Units Ordered In:	Status 4/76	Estimated Capital Cost $/KWe 1/75	Estimated Capital Cost $/KWe 4/76
1973				1974			
Palo Verde 1	C/P	495	788	Barton 3	Can.	610	CANCELED
Palo Verde 2	C/P	473	683	Barton 4	Can.	628	CANCELED
Palo Verde 3	C/P	489	767	South River 1	--	n.a.	n.a.
Perkins 1	C/P	581	663	South River 2	--	n.a.	n.a.
Perkins 2	C/P	581	663	South River 3	--	n.a.	n.a.
Perkins 3	C/P	581	663	Central Maine Power	--	667	696
Cherokee 1	C/P	583	672	Zimmer 2	--	427	946
Cherokee 2	C/P	583	672	Blue Hills 2	C/P	558	558
Cherokee 3	C/P	583	672	Iowa P & L	Can.	700	CANCELED
Blue Hills 1	C/P	659	659	Jamesport 2	C/P	632	802
River Bend 2	LWA	545	545	St. Rosalie 1	Can.	517	CANCELED
Allen's Creek 1	C/P	545	528	St. Rosalie 2	Can.	517	CANCELED
Allen's Creek 2	C/P	545	528	NEES 1	--	693	687
South Texas 1	C	460	541	NEES 2	--	693	687
South Texas 2	C	460	541	Montague 1	C/P	561	697
Clinton 1	C	466	756	Montague 2	C/P	561	626
Clinton 2	C	393	647	Ft. Calhoun 2	C/P	671	775
Wolf Creek	C/P	817	817	Pebble Springs 2	C/P	595	595
Jamesport 1	C/P	698	882	Cementon	C/P	603	672
Millstone 3	C	555	874	Marble Hill 1	C/P	522	658
Tyrone 1	C/P	783	783	Marble Hill 2	C/P	522	549
Pebble Springs 1	C/P	511	710	Skagit 2	C/P	556	559
Atlantic 3	--	609	609	Yellow Creek 1	--	346	715
Atlantic 4	--	609	609	Yellow Creek 2	--	356	715
Black Fox 1	C/P	421	348	Phipps Bend 1	C/P	346	633
Black Fox 2	C/P	421	348	Phipps Bend 2	C/P	346	633
Skagit 1	C/P	705	771	Nuclear Project 4	LWA	521	900
Sterling	C/P	698	696	Nuclear Project 5	C/P	573	1023
Davis-Besse 2	LWA	667	746	1974 Average		549	690
Davis-Besse 3	LWA	780	854	1975			
Callaway 1	LWA	749	714	South Dade 1	--	577	820
Callaway 2	LWA	719	670	South Dade 2	--	577	778
Koshkonong 1	C/P	572	722	Sundesert 1	--		572
Koshkonong 2	C/P	474	722	Sundesert 2	--		572
Nuclear Project 3	C/P	600	1000	1975 Average			694
1973 Average		583	678				

*Reclassified by AEC as a 1968 plant in 1970.

**Construction halted under court order.

[Status 4/76: --, no application for construction permit; LWA -- limited work authorization while construction permit pending; C/P -- construction permit pending; C -- construction permit granted; O/P -- operating permit pending; O -- (date) -- operating permit granted, commercial operation of (date)].

Averages per year are average capital cost per KWe for plants not yet in commercial operation.

Source: "Central Station Nuclear Plants," ERDA, selected issues, 1968-1976.

APPENDIX B

DELAYS IN THE ISSUANCE OF CP FOR UNITS APPLYING FOR CP, 1966-1970

A. Units Applying for CP in 1966

Unit	Time To Obtain CP	Intervenors	Comments
Fort St. Vrain	23	Yes	First large gas cooled reactor. Delay due to time required for staff and ACRS reports.
Salem 1	21	Yes	Delay due to change in plant site after initial application.
Vermont Yankee	13	Yes	Delay due in part (4-5 months) to intervenors (environmental issues).
Turkey Point 3, 4	13	Yes	Delay due to ACRS and staff reports. CP contains condition raised by intervenor.
Oconee 1, 2	12	Yes	Three months delay due to intervenor ("practical value" issue).
Point Beach 1	11	Yes	No delay due to intervenor.
Monticello	10	No	First field erected pressure vessel; not a source of delay
Browns Ferry 1, 2	10	No	ACRS delays CP by two months -- diesel generator system
Palisades	9	No	No problems.
Robinson 2	9	No	No problems.
Quad Cities 1	9	No	First case involving multiple units at one site; not a source of delay
Dresden 3	8	No	No problems. Identical to Dresden 2, already under construction.
Quad Cities 2	6	No	See Quad Cities 1.

APPENDIX B

(Continued)

B. Units Applying for CP in 1967

Unit	Time To Obtain CP	Intervenors	Comments
Indian Point 3	28	Yes	22 months from application to notice of hearing. Safety issues raised by intervenors. Appeals, CP affirmed.
Zion 1 Zion 2	17 16	No No	ACRS concern with population density; staff-LB differences on safety issues, ownership of Commonwealth Edison. Appeal on ownership issue, CP affirmed by AEC.
Surry 1, 2	15	No	13 months from application to notice of hearing. No problems.
Diablo Canyon	15	Yes	Seismicity issue raised; no problems due to intervenors
Prairie Island 1, 2	15	Yes	Safety issues raised; no delays due to intervenor (application changed from 1 to 2 units).
Cook 1, 2	15	No	No apparent problems - 12 months for ACRS, staff reports.
Pilgrim	14	Yes	"Practical value" intervenors - some accepted, some denied standing. Appeals, denied
Fort Calhoun	14	No	Staff-LB differences. CP is conditioned. AEC later rejects conditions.
Crystal River	13	Yes	"Practical value" raised. CP is conditioned, but no apparent delays due to intervenors. Appealed, CP affirmed
Maine Yankee	13	No	"Practical value" intervenors denied standing. Problem with financial qualifications of applicant, OK'd two years later.
Ark. Nuclear 1	13	No	Uncontested. No problems.
3 Mile Island	12	Yes	Uncontested. Proximity to airport a minor problem.
Kewaunee	12	Yes	Uncontested. No problems.
Point Beach 2	12	Yes	Uncontested. No problems
Browns Ferry 3	12	No	No problem.
Peach Bottom 2, 3	11	Yes	"Practical value" intervenors, no delay. Appealed, CP affirmed.
Cooper	11	No	Several amendments filed prior to hearing, but no delay problems with them.

APPENDIX B

(Continued)

B. Units Applying for CP in 1967
(Continued)

Unit	Time To Obtain CP	Intervenors	Comments
Rancho Seco	11	No	LB notes that if there had been intervenor, more complete staff study would have been needed.
Salem 2	11	Yes	Intervenor issues related to OL not CP. No problems.
Oconee 3	7	Yes	"Practical value" intervenors denied standing. Various appeals, all denied.

C. Units Applying for CP in 1968

Unit	Time To Obtain CP	Intervenors	Comments
Shoreham	59	Yes	Intervenor objects to ASLB's application of NEPA, raises bias issue, claims work being done without CP, raises freedom of information issues, various appeals to ASLAB, all rejected. Length of time related to NEPA FES requirements.
Diablo Canyon 2	30	Yes	17 months from CP application to notice of hearing. Delays in hearings due to seismic issues. NEPA issues raised by intervenors. Appealed, CP affirmed even though by time of AB decision, procedures have changed. On second appeal (1973) results in conditions on CP, several issues raised by intervenor, suspension of some construction.
3 Mile Island 2	19	No	Uncontested. 16 months from CP application to notice of hearing.
Brunswick 1, 2	19	No	"Practical value" intervention denied. Appeal, denial (at CP stage) affirmed. (five month suspension of construction for NEPA reasons occurs from 11/71-4/72).
Arnold 1	19	Yes	3 month delay relating to financial qualifications of applicant; involved a dispute with REA. Reviewed and affirmed by AB.

APPENDIX B

(Continued)

C. Units Applying for CP in 1968
(Continued)

Unit	Time To Obtain CP	Intervenors	Comments
Sequoyah 1, 2	19	No	15 months for staff safety evaluation. Uncontested. First CP since NEPA passed, No major delays due to NEPA.
Calvert Cliffs 1, 2	18	Yes	Safety issues raised by intervenors rejected. Appealed, CP affirmed by AEC. (Environmental court case occurs after CP issuance.)
Fitzpatrick 1	17	No	No problems, except coordination with state agency regarding releases into Lake Ontario.
Hatch 1	16	No	Uncontested. No problems.

D. Units Applying for CP in 1969

Unit	Time To Obtain CP	Intervenors	Comments
Midland 1, 2	47	Yes	Safety issues raised by intervenor, led into freedom of information appeals, rejected by AB, claim construction occurring before CP issuance rejected by AB, also rejected by AEC, various other motions denied by AB. Delays apparently due to intervenors. CP appealed, affirmed. Bias of LB claimed, denied. Petition to strengthen quality assurance during construction denied.
Fermi 2	41	No	Uncontested. 24 months from CP application to notice of hearing. Reviewed by AB because of discrepancies between staff and LB on "as low as practicable" calculations. CP affirmed after lecture to LB on resolving such issues at CP hearing.
Farley 1	34	Yes	First case involving an environmental hearing pursuant to NEPA, Calvert Cliffs decision. 21 months from CP application to notice of hearing. Intervenors raised need for power and environmental issues. All rejected, monitoring of weather and noise data required of applicant. No appeals.

APPENDIX B
(Continued)

D. Units Applying for CP in 1969
(Continued)

Unit	Time To Obtain CP	Intervenors	Comments
North Anna 1, 2	23	Yes	Environmental issues raised, dismissed as beyond AEC scope. CP later conditioned to meet NEPA conditions.
Millstone 2	20	Yes	CP issued with condition requiring compliance with state and federal environmental standards. Environmental issues raised by intervenors are rejected. Appealed, CP affirmed by AB.
Davis Besse 1	20	Yes	"Practical value" intervenors denied standing. Appeal, affirmed. Bias issue raised, rejected by AEC, safety issues, environmental issues, meteorological issues raised and rejected. Appeal, CP affirmed. Stay of construction petition denied by AB. 4/72, court orders hearing on stay for NEPA review. Hearing held, stay again denied. Appealed to AEC, again stay denied.
Trojan	20	Yes	Environmental issues and "as low as practicable" safety issues raised by intervenors. 14 months from CP application to notice of hearing. LB rejects intervenor contentions. Appealed, CP affirmed. 4/72, petition for stay of construction for NEPA review. Intervenors and applicant reach agreement before hearing on petition. No stay of construction.
St Lucie 1	18	Yes	Compromise with one intervenor on use of river water before hearing, intervenor withdraws. State of Florida accepts an agreement to obey environmental laws of the state. Staff appeals on the basis of the language of this condition. AB accepts staff recommendation.
Beaver Valley 1	17	Yes	Uncontested decision. 16 months CP application to prehearing conference. Only problem is staff recommendation for second containment structure.

APPENDIX B

(Continued)

E. Units Applying for CP in 1970

Unit	Time To Obtain CP	Intervenors	Comments
Northcoast Power	-	-	Withdrew after CP application.
Hope Creek 1, 2	57	Yes	21 months from CP application to establishment of LB. Site changed during CP process. New LB appointed 47 months after CP application. Intervenors withdraw before CP hearing on basis of agreement with applicant.
Limerick 1, 2	51	Yes	21 months from CP application to notice of hearing. Delay of licensing for 13 months due to environmental hearing. Intervenor raised safety issues, seismic, quality assurance, water supply. CP conditioned to require EIS on water reservoir.
Waterford 3	47	Yes	"Practical value" intervention permitted. Procedural delays associated with individual intervenor. Anti-trust a major issue. Safety and environmental issues raised at CP hearing, intervenor items rejected by LB. CP includes conditions relating to anti-trust issues. Reviewed by AB and affirmed.
Bailly	45	Yes	13 months from CP application to establishment of ASLB. Issues raised by intervenors, appealed to AB and AEC and rejected, including intimidation of one of intervenors witnesses, bias, quorum problems, freedom of information, new evidence. Intervenors obtain temporary stay of CP, condition on CP. Case taken to circuit court. CP reopened 10/74 because of court decision. No substantive changes in CP.
San Onofre 2, 3	41	Yes	Several prehearings and hearings (8 months between first prehearing and final hearing). Safety, seismic issues raised. LB rules underground siting not feasible as a practical alternative. CP issued with several conditions. Later, 1/74, California Coastal Commission bans construction; 2/20/74, construction permitted subject to conditions. AB rejects intervenor petition that AEC continue California ban on construction.

APPENDIX B

(Continued)

E. Units Applying for CP in 1970
(Continued)

Unit	Time To Obtain CP	Intervenors	Comments
Forked River 1	37	Yes	Uncontested. 26 months from CP application to establishment of ASLB. New Jersey wants a condition in CP making New Jersey air pollution code binding. Rejected by LB.
LaSalle 1, 2	34	Yes	Environmental issues; LB includes monitoring requirements in CP. AB and AEC review the CP decision, find quality assurance problems. Applicant changes QA organization so that no stays or further conditions imposed on CP. Applicant succeeds (at AB level) in disqualifying one member of LB.
Zimmer 1	29	No	Uncontested. 23 months from CP application to notice of hearing. AB remands the case because of inadequate record relative to cooling tower, no stay of construction. LB heard additional testimony and recommended no change. AB affirms CP.
McGuire 1, 2	29	Yes	"Practical value intervenors denied standing. 233 items introduced by remaining intervenors; all are rejected by staff and LB.
Hatch 2	29	No	Uncontested. 24 months from CP application to notice of hearing. Essentially identical to Unit 1 under construction. 16 amendments to PSAR during staff review. Monitoring requirements included as condition of CP. No appeals.
Ark. Nuclear 2	27	No	Uncontested. Staff appeals condition attached to CP. AB affirms LB's condition.
Farley 2	26	Yes	"Practical value" and environmental issues. Exemption granted by LB to begin construction 16 months before CP issued.

APPENDIX C

SUSPENDED OR CANCELED NUCLEAR POWER PLANTS BETWEEN 1970-1977 WITH OUTSTANDING NSSS ORDER

Year of Suspension or Cancellation	Name	Owner	Reactor Supplier	Year of NSSS Order
(1) 1970	Malibu	LADWP	W	63
(1) 1971	Unit 4	Carolina P & L	GE	68
(5) 1972	Bell	NYSGE	GE	67
	Verplanck 1 & 2	Consolidated Edison	GE	68 & 69
	Waterford 4	Louisiana P & L	W	70
	Crystal River 4	Florida Power		71
(5) 1973	Aguirre	PRWRA	W	70
	Mendocino 1 & 2	PG & E	GE	71
	Perryman 1 & 2	Baltimore Electric	Comb.	72
(11) 1974	Vogtle 1 & 2	Georgia Power	W	71
	Quanicasse 1 & 2	Consolidated Power	W	72
	Vidal 1 & 2	SCE	GA	72
	Fermi 3	Detroit	GE	72
	Tyrone 2	Northern States Power	W	73
	Boardman	Portland	B & W	73
	Off Shore 1 & 2	Jacksonville E.A.	OPS	74
(6) 1975	Fulton 1 & 2	Philadelphia Electric	GA	71
	Allens Creek 1 & 2	Houston Light and Power	GE	73
	St. Rosalie 1 & 2	Louisiana	GA	74
(10) 1976	Summit 1 & 2	Delmarva	GA	71
	Barton 1 & 2	Alabama	GE	72
	Barton 3 & 4	Alabama	GE	74
	NORCO-NP-1	PRWRA	W	74
	Unit 2 & 3	Florida Power	Comb.	74
	Iowa Power and Light		GE	74
(8) 1977	Douglas Point	Potamac Electric Power	GE	72
	Surry 3 & 4	Virginia Electric Power	B & W	72
	Sears Island	Central Maine	W	74
	South Dade 1 & 2	Florida P & L	W	75
	Vandalia	Iowa Power	B & W	76

Source: Electrical World, 1965-1977, U.S. Central Station Nuclear Electrical Generation Units: Significant Milestones, 1965-1977.

Tables in this appendix were prepared by Katsuaki Terasawa, Jet Propulsion Laboratory.

APPENDIX C

NUCLEAR POWER PLANTS
DELAYS IN EXPECTED COMMERCIAL OPERATION DATE
BETWEEN 1970-1977

Year of NSSS Order	Number of Order	Average Delay In							Ranges in Annual Delays	Number of Plants Suspended or Canceled	Average Length (Yrs.) of Approval Since NSSS Order	
		70-71	71-72	72-73	73-74	74-75	75-76	76-77			CP	OL
65	7	.6	.5	1.0		1.0	2.0		0-5	0	1.5	6
66	21	.6	.8	.4	.5	.3	.5	.5	0-5	1	1.5	6
67	31	.4	.7	.5	.7	.6	.8	0	0-8	1	2.5	8
68	16	1.0	.4	.5	.6	.9	.5	0	1-8	2	3.0	
69	8	.4	.9	1.0	.8	.9	1.0	.1	2-9	1	3.5	
70	15	.3	1.0	.5	.5	.7	.5	.1	2-7	2	3.5	
71	21		.3	.5	1.6	1.9	.7	.4	3-11	9	4.0	
72	38			.2	1.0	1.1	.7	.5	1-8	13		
73	37				.9	.7	.8	.8	1-8	4		
74	33				1.8	1.0	1.2	.1	1-9	11		
75	4						-1.5	.5	(1)-1	2		
76	3							2.0	0-2	1		
77												

Source: Electrical World, 1965-1977, U.S. Central Station Nuclear Electrical Generation Units: Significant Milestones, 1965-1977.

Note: For each year entries to the left of the solid line reflect delays in CP. Entries to the right of the broken line indicate delays after OL has been issued. The entries bordered by the broken and solid line reflect delays after CP is issued but prior to OL issuance.

APPENDIX C

UNITS ORDERED IN 1965*[1,2]

PLANT	1970			1971			1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR OL ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
1. Dresden 2	70																									-70
2. Ft. S. Vrain	72	70		72	95		73	99	1	74	99	1	74			75		1	77		2	77			5	73
3. Ginna	70																									-70
4. Pilgrim 1	71	70		72	95	1	72																		1	72
5. Millstone 1	70			71		1																			1	70
6. Ind. Pt. 2	71			71			72		1	73		1													2	71
7. Turkey Point	71	75		72	95	1	72																		1	72
Aggregate Delays (Years)						3			2			2						1			2				10	

*1. Announcements were also made in 1965.

*2. Information for the year 1970 through 1975 are based upon the October issues of Electrical World. Information for 1976 and 1977 are based upon ERDA publication, U.S. Central Station Nuclear Electrical Generation Units: Significant Milestones, October 1976 and July 1977.

APPENDIX C

UNITS ORDERED IN 1966

PLANT	1970			1971			1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR OL ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
1. Dresden 3	70	75		71		1																			1	71
2. Palisades	71			71																						71
3. Robinson 2	70			71		1																			1	70
4. Point Beach 1	70																									70
5. Monticello	70			71		1																			1	70
6. Quad Cities	71	80					73		2																2	71
7. Browns Fer. 1	71	70		72	90	1	73	98	1	73	99		74		1										3	73
8. Browns Fer. 2	72	50		73	70	1	74	70	1	74	80		74	99		75		1							3	74
9. Oconee 1	71	70		71	·99		73	99	2	73															2	73
10. Oconee 2	72	40		72	70		73	80	1	73	99		74		1										2	73
11. Quad Cities 2	72	50		72	85					73		1													1	72
12. Peach Bot. 2	72	60		73	80	1	73	90		74		1	74												2	73
13. Peach Bot. 3	73	30		74	50	1	74	50		74	85		74												1	74
14. Salem 1	72	30		73	60	1	74	70	1	75	75	1	76	85	1	76	95		76			77		1	5	76
15. Vermont Yan.	71	70		71	99		72		1																1	72
16. Ft. Calhoun 1	71	50		72	65	1	73	90	1	73															2	73
17. Surry 1	71	65		72	95	1	72																		1	72
18. Surry 2	72	35		72	65		73	96	1	73															1	73
19. Diablo 1	73	35		74	30	1	75	50	1	75	75		76	90	1	76	93		77	99	1	77			4	
20. 3 Mile Isl. 1	72	40		72	75		72	90		74	95	2	74												2	74
Aggregate Delays (Years)						11			12			5			4			1			1			1	35	

Easton*

*Niagara Mohawk Power, 750 MW, GE scheduled operation 71 (according to Electrical World, 1968) was ordered in 1966 and later canceled to become Fitzpatrick in 1968.

APPENDIX C

UNITS ORDERED IN 1967*

PLANT	1970			1971			1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED	YEAR OL ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year			
1. Bailey	76			76			77		1	78		1	79		1		5		82	25	3	82			6	74	
2. Crystal R. 3	72	10		73	40	1	74	55	1	75	80	1	75	93		76	93	1	77		1	77			5	-70	76
3. Kewaunee 1	72	40		73	70	1	73	93		73	99		74		1										2	-70	73
4. M. Yankee	72	40		72	90		72																			-70	72
5. Pt. Beach 2	71	50		72	95	1				73		1													2	-70	71
6. Prairie Isl. 1	72	40		72	75		73	90	1	73															1	-70	73
7. Shoreham	75			76†		1	77		1	77	5		78	20	1	78	35		79	52	1	79			4	73	
8. 3 Mile Isl. 2	73	5		74	20	1	75	25	1	76	45	1	77	60	1	78	70	1	78	85		78			5	-70	
9. Zion 1	72	40		72	70		72			73		1													1	-70	73
10. Arkansas 1	73	25		73	60		73	85		74	99	1	74												1	-70	74
11. Cooper	72	40		73	55	1	73	85		74	98	1	74												2	-70	74
12. Indian Pt. 3	73	30		73	60		74	70	1	74	85		75	93	1	76	99	1	76		1				3	-70	75
13. Turkey Pt. 4	72	60		72	80		73	97	1	73															1	-70	73
14. Calvert Cl. 1	73	25		73	55		74	70	1	74	85		74	96		75		1							2	-70	74
15. Calvert Cl. 2	74	15		74	35		75	55	1	75	70		77	68	2	77	85		77			77			3	-70	76
16. Oconee 3	73	15		73	40		74	45	1	74	89		74												1	-70	74
17. Salem 2	73	15		74	40	1	75	35	1	76	32	1	79	45	3	79	55		79	59		79			6	-70	

-CONTINUED-

APPENDIX C

UNITS ORDERED IN 1967*

-CONTINUED-

PLANT	1970			1971			1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED	YEAR OL ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year			
18. Browns Fer. 3	72	30		73	50	1	74	40	1	75	35	1	75	75		76	93	1	77	99	1	77			5	-70	76
19. Prairie Isl. 2	74	20		74	45		74	35		74	65		74													-70	74
20. Cook 1	72	20		73	50	1	73	75		74	95	1	75	96	1	75									3	-70	74
21. Cook 2	73	10		74	30	1	75	50	1	76	60	1	76	51		78	57	2	78	85		78			5	-70	
22. Zion 2	73	25		73	50		73			74	90	1	74												1	-70	73
23. Rancho Seco	73	30		73	50		74	75	1	74	93		75	99	1	75									2	-70	74
24. Beaver Valley	73			74	30	1	74	50		74	65		75	92	1	76	99	1	76						3	70	76
25. Limerick 1	75			75			79		4	79	1		81	2	2	81	17		83	30	2	83			8	74	
26. Limerick 2	77			77			80		3	81	1	1	83	1	2	83	4		85	19	2	85			8	74	
27. North Anna 1	74			75	20	1	75	50		75	60		75	80		77	85	2	77	96		77			3	71	
28. Hatch 1	73	30		73	55		74	65	1	74	90		74			75		1							2	-70	74
29. St. Lucie	73	5		74	25	1	74	37		73	60	1	75	80		75	98		76		1				3	70	76
30. Millstone 2	74			74	25		74	45		75	70	1	75	90		75									1	70	75
31. Bell										C	A N	C E	L E	D													
Aggregate Delays (Years)						13			22			15			17			11			11				89		

*Announcements were made in 1967 except for the following eight plants: Maine Yankee (66), Shoreham (65), Cooper (66), Turkey Pt. 4 (65), Salem 2 (66), Cook (66), Rancho Seco (66), St. Lucie (68).

†Public hearing delayed.

APPENDIX C

UNITS ORDERED IN 1968[1]

PLANT	1970			1971			1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED	YEAR OL ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year			
1. Brunswick 1	75	5		76	15	1	73	35	-1	75	50		75	65		77	75	2	77	96		77			2	70	76
2. Brunswick 2	74	10		74	30		74	65		74	80		75	90	1	75									1	70	74
3. Arnold 1	73			74	25	1	73	70	-1	74	96	1	74			75		1							2	70	74
4. Sequoyah 1	73			74	25	1	74	45		75	55	1	76	90	1	77	69	1	78	80	1	78			5	70	
5. Sequoyah 2	74			75	15	1	75	35		76	45	1	77	60	1	78	69	1	79	70	1	79			5	70	
6. Midland 1	74			76		2	18		2	80		2	80	5		82	10	2	82	17		82			8	72	
7. Midland 2	75			77		2	79		2	79	5		79	10		81	10	2	81	17		81			6	72	
8. Susquehana 1	77			78		1	79		1	79			80	5	1	80	13		80	33		80			3	73	
9. Susquehana 2	79			80		1	81		1	81			82	5	1	82	5		82	22		82			3	73	
10. Diablo 2	74			75	5	1	76	12	1	76	35		76	50		77	60	1	78	83	1	78			4	70	
11. Fermi 2	74			75		1	76		1	77	40	1	79	45	2	80		1	80	45		80			6	72	
12. Davis Besse 1	74			75	15	1	75	35		75	55		76	68	1	76	90		77	99	1	77			3	71	
13. Trojan	74			75	10	1	74	55	-1	74	75		75	85	1	75	95		76		1				2	71	75
14. Fitzpatrick	73			73	35		73	75		74	93	1	74	99		75		1							2	70	74
Aggregate Delays (Years)						14			5			7			9			12			5				52		
15. Carolina P & L Unit 4[2]											O	P	E	N													
16. Verplanck 1[3]	75			77	78	1				D	E	L	A	Y	D												
Aggregate Delays (Years)						1																					

1. Announcements were made in 1968 except for the following four plants: **Midland 1, 2, Susquehana 1, Trojan. These announcements** were made in 1967.

2. 821 MW station supplied by GE was announced on January 24, 1968.

3. Consolidated Edison 1,125 MW, GE-BWR (Peeksville, New York) is delayed due to uncertainty on cooling system. Announcements were made on January 10, 1968.

APPENIDX C

UNITS ORDERED IN 1969*

PLANT	1970			1971			1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commerical Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
1. Farley 1	75			75			75	27		75	50		76	75	1	76	85		77	90	1	77			2	72
2. Hope Creek 1	75			75			78		3	81		3	81			82		1	84	1	2	84			9	74
3. Hope Creek 2	77			77			79		2	82		3	83		1	84		1	86	1	2	86			9	74
4. Zimmer 1	75			76		1	77		1	77	5		77	18		79	30	2	79	65		79			4	72
5. McGuire 1	75			75			75	5		76		1	78		2	78	55		79	80	1	79			4	73
6. McGuire 2	77			77			77	5		77			79		2	79	43		80	55	1	80			3	73
7. Forked Riv. 1	76			78		2	78			78			80		2	82		2	82	0		83		1	7	73
8. Verplanck 2†	77			77	78					D	E	L	A	Y	E	D										
Aggregate Delays (Years)						3			6			7			8			6			7			1	38	

*Announcements were made in 1969 for all units except for Zimmer 1 (68) and Forked River (68).

†Consolidated Edison, General Electric, Peeksville, New York was announced June 3, 1969.

APPENDIX C

UNITS ORDERED IN 1970[1]

PLANT	1970 Expected Date of Commercial Operation	1970 Percent Progress	1970 Delay in Commercial Op. vis-a-vis Previous Year	1971 Expected Date of Commercial Operation	1971 Percent Progress	1971 Delay in Commercial Op. vis-a-vis Previous Year	1972 Expected Date of Commercial Operation	1972 Percent Progress	1972 Delay in Commercial Op. vis-a-vis Previous Year	1973 Expected Date of Commercial Operation	1973 Percent Progress	1973 Delay in Commercial Op. vis-a-vis Previous Year	1974 Expected Date of Commercial Operation	1974 Percent Progress	1974 Delay in Commercial Op. vis-a-vis Previous Year	1975 Expected Date of Commercial Operation	1975 Percent Progress	1975 Delay in Commercial Op. vis-a-vis Previous Year	1976 Expected Date of Commercial Operation	1976 Percent Progress	1976 Delay in Commercial Op. vis-a-vis Previous Year	1977 Expected Date of Commercial Operation	1977 Percent Progress	1977 Delay in Commercial Op. vis-a-vis Previous Year	TOTAL DELAY 1970-1977	YEAR CP ISSUED
1. North Anna 2	75			75	50		75	50		76	40	1	76	60		77	55	1	78	74	1	78			3	71
2. San Onofre 2	75			76		1	78		2	78			80	5	2	81	8	1	81	27		81			6	73
3. San Onofre 3	76			77		1	79		2	79			81	5	2	83	8	2	83	27		83			7	73
4. Hatch 2	76			76			77	5	1	78	15	1	78	25		79	30	1	79	70		79			3	72
5. Aguirre[2]	75			76		1	78	5	2																3	
6. Arkansas 2	76			77		1	77	7		77	16		77	37			49		78	76	1	78			2	72
7. LaSalle 1	75			75			77		2	78		1	78	5		78	15		79	40	1	79			4	73
8. LaSalle 2	76			76			78		2	79		1	79	5		79	10		79	35		80		1	4	73
9. Bellefonte 1	77			77			79		2	79			79			80	5	1	80	24		80			3	74
10. Bellefonte 2	78			78			79		1	80		1	80			81	5	1	81	16		81			3	74
11. Watts Bar 1	76			77		1	77			78	5	1	78	13		78	25		79	51	1	79			3	73
12. Watts Bar 2	77			77			78		1	78	5		79	13	1	79	25		80	43	1	80			3	73
13. Waterford 3				77			77			78[3]		1	79		1	81	2	2	81	17		81			4	74
14. Farley 2	77			77			77			77	15		77	30		77	45		79	40	2	79			2	72
15. Waterford 4[4]				78																						
Aggregate Delays (Years)						5			15			7			6			9			7			1	50	

1. Announcements are made in 1970 for all units except North Anna (67).

2. Original location Guayama, P.R. is canceled. New project NORCO-NP-1 is announced in September of 1974.

3. Public hearing and antitrust delays.

4. Louisiana Power and Light 1,165 MW (C-E, PWR: Westinghouse) announced September 24, 1970.

APPENDIX C

UNITS ORDERED IN 1971

PLANT	1971 Expected Date of Commercial Operation	1971 Percent Progress	1971 Delay in Commercial Op. vis-a-vis Previous Year	1972 Expected Date of Commercial Operation	1972 Percent Progress	1972 Delay in Commercial Op. vis-a-vis Previous Year	1973 Expected Date of Commercial Operation	1973 Percent Progress	1973 Delay in Commercial Op. vis-a-vis Previous Year	1974 Expected Date of Commercial Operation	1974 Percent Progress	1974 Delay in Commercial Op. vis-a-vis Previous Year	1975 Expected Date of Commercial Operation	1975 Percent Progress	1975 Delay in Commercial Op. vis-a-vis Previous Year	1976 Expected Date of Commercial Operation	1976 Percent Progress	1976 Delay in Commercial Op. vis-a-vis Previous Year	1977 Expected Date of Commercial Operation	1977 Percent Progress	1977 Delay in Commercial Op. vis-a-vis Previous Year	TOTAL DELAY 1970-1977	YEAR CP ISSUED
1. Mendochino 1[1]	77			79		2																2	
2. Mendochino 2	77			79		2																2	
3. Summer 1	77			77			78		1	78	5		79	17	1	79	45		80		1	3	73
4. WPPSS 2[2]	77			77			77	2		78	10	1	78	23		80	35	2	80			3	73
5. Harris 1	77			77			78		1	81		3	84	5	3	84	<5		84			7	
6. Harris 2	78			78			79		1	82		3	86	5	4	86	<5		86			8	
7. Harris 3	79			79			80		1	83		3	90	5	7	90	<5		90			11	
8. Harris 4	80			80			81		1	84		3	88	5	4	88	<5		88			8	
9. Byron 1	78			78			79		1	80		1	80	1		80	15		81		1	3	75
10. Byron 2	79			79			80		1	81		1	82	1	1	82	10		82			3	75
11. North Anna 3	77			77			77			78	5	1	80	5	2	81	4	1	82		1	5	74
12. North Anna 4[3]	78			78			78			79	2	1	81	2	2	81	2		83		2	5	74
13. Vogtle 1[4]	78			80		2	80									83	0	3	83			5	74
14. Vogtle 2	79			81		2	81									84	0	3	84			5	74
15. Beaver Valley 2				78			78			81		3	81			82		1	82			4	74
16. Nine Mile Point 2				78			78			80		2	82	1	2	82	5.5		82			4	74
17. Summit 1				79			79			80		1	81		1								
18. Summit 2				82			82			82			84		2								
19. Fulton 1	79			79			81		2	84		3											
20. Fulton 2	79			81		2	83		2	86		3											
Aggregate Delays (Years)						6			11			29			29			10			5	90	

1. PG & E Units. Alternate sites under consideration. Aggregate Delays (Years) are not shown for this plant.

2. WPPSS announcement was made in February of 1967, all the rest were made in 1971.

3. Future status of this unit is currently under review.

4. Georgia Power Company units were suspended in September of 1974.

APPENDIX C

UNITS ORDERED IN 1972[1]

PLANT	1972 Expected Date of Commercial Operation	1972 Percent Progress	1972 Delay in Commercial Op. vis-a-vis Previous Year	1973 Expected Date of Commercial Operation	1973 Percent Progress	1973 Delay in Commercial Op. vis-a-vis Previous Year	1974 Expected Date of Commercial Operation	1974 Percent Progress	1974 Delay in Commercial Op. vis-a-vis Previous Year	1975 Expected Date of Commercial Operation	1975 Percent Progress	1975 Delay in Commercial Op. vis-a-vis Previous Year	1976 Expected Date of Commercial Operation	1976 Percent Progress	1976 Delay in Commercial Op. vis-a-vis Previous Year	1977 Expected Date of Commercial Operation	1977 Percent Progress	1977 Delay in Commercial Op. vis-a-vis Previous Year	TOTAL DELAY 1970-1977	YEAR CP ISSUED
1. Grand Gulf 1	79			79			79	<5		79	10		80	35	1	80			1	74
2. Grand Gulf 2				80			81	<5	1	83	5	2	83	2		83			3	74
3. Pilgrim 2	78			80		2	80			82		2	82			84		2	6	
4. Greenwood 2[2]	80			80			82		2	84		2	84			87		3	7	
5. Greenwood 3	81			82		1	84		2	86		2	86			89		3	8	
6. Perry 1	79			79			79			80	1	1	81	4	1	81			2	
7. Perry 2	80			80			80			82	1	2	83	4	1	83			3	
8. Seabrook 1	79			79			79			80		1	81	<5	1	81			2	76
9. Seabrook 2	81			81			81			82		1	83	<5	1	83			2	76
10. River Bend 1	79			80		1	80			81		1	81	1		83		2	4	77
11. Catawba 1	79			79			81		2	81			81	<5		81			2	75
12. Catawba 2	80			80			82		2	82			82	<5		83		1	3	75
13. AGS 1	80			80			85		5	85			85			85			5	
14. AGS 2	80			81		1	87		6	87			87			87			7	
15. Douglas Point 1				80			82		2	85		3	85						5	
16. Douglas Point 2				82			84		2	87		3	87						5	
17. Braidwood 1				79			80		1	81		1	81	5		81			2	75
18. Braidwood 2				80			81		1	82		1	82	5		82			2	75
19. Comanche Peak 1				80			80			80	5		80	25		81		1	1	74
20. Comanche Peak 2				82			82			82			82			83			1	74
21. Clinch River													84			84[3]				
22. St. Lucie 2[4]				79			80		1	80			82		2	83		1	4	
23. WPPSS 1				80			80			80			81	2	1	81			1	75

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APPENDIX C

UNITS ORDERED IN 1972[1]

-CONTINUED-

PLANT	1972 Expected Date of Commercial Operation	1972 Percent Progress	1972 Delay in Commercial Op. vis-a-vis Previous Year	1973 Expected Date of Commercial Operation	1973 Percent Progress	1973 Delay in Commercial Op. vis-a-vis Previous Year	1974 Expected Date of Commercial Operation	1974 Percent Progress	1974 Delay in Commercial Op. vis-a-vis Previous Year	1975 Expected Date of Commercial Operation	1975 Percent Progress	1975 Delay in Commercial Op. vis-a-vis Previous Year	1976 Expected Date of Commercial Operation	1976 Percent Progress	1976 Delay in Commercial Op. vis-a-vis Previous Year	1977 Expected Date of Commercial Operation	1977 Percent Progress	1977 Delay in Commercial Op. vis-a-vis Previous Year	TOTAL DELAY 1970-1977	YEAR CP ISSUED
24. Hartsville 1				80			80			81		1	83	1	2	83			3	
25. Hartsville 2				81			81			82		1	84	1	2	84			3	
26. Hartsville 3				81			81			82		1	83	1	1	83			2	
27. Hartsville 4				82			82			83		1	84	1	1	84			2	
28. Barton 1				82			84		2	83		-1								
29. Barton 2				83			85		2	84		-1								
30. Surry 3[5]				80			80			83		3	86	.5	3				6	
31. Surry 4				81			81			84		3	87	.5	3				6	
32. Fermi 3 [6]				81																
33. SCE/HTGR 1[7]	81			82[8]			83													
34. SCE/HTGR 2	82			83[9]																
35. Quanicasse 1				81																
36. Quanicasse 2				82																
37. Perryman 1	79																			
38. Perryman 2	80																			
Aggregate Delays (Years)						5			27			32			20			14	98	

1. Announcement Order year are the same for all units except Grand Gulf 1, 2 (71) and AGS 1, 2 (71).

2. Engineering and construction suspended for financial reasons.

3. United States Government.

4. Construction suspended in November of 1976. Florida Power and Light.

5. Virginia Electric Company 859 MW, B & W-PWR, announcement was made in September of 1972. Construction Permit was issued in December of 1974.

6. Detroit Edison, 1,220 MW, GE-BWR, Portland Oregon was announced April 5, 1972.

7. Desert site, 770 MW, announcement made in May of 1972.

8. Vidal 1.

9. Vidal 2.

APPENDIX C

UNITS ORDERED IN 1973

PLANT	1971 Expected Date of Commercial Operation	1971 Percent Progress	1971 Delay in Commercial Op. vis-a-vis Previous Year	1972 Expected Date of Commercial Operation	1972 Percent Progress	1972 Delay in Commercial Op. vis-a-vis Previous Year	1973 Expected Date of Commercial Operation	1973 Percent Progress	1973 Delay in Commercial Op. vis-a-vis Previous Year	1974 Expected Date of Commercial Operation	1974 Percent Progress	1974 Delay in Commercial Op. vis-a-vis Previous Year	1975 Expected Date of Commercial Operation	1975 Percent Progress	1975 Delay in Commercial Op. vis-a-vis Previous Year	1976 Expected Date of Commercial Operation	1976 Percent Progress	1976 Delay in Commercial Op. vis-a-vis Previous Year	1977 Expected Date of Commercial Operation	1977 Percent Progress	1977 Delay in Commercial Op. vis-a-vis Previous Year	TOTAL DELAY 1970-1977	YEAR CP ISSUED
1. Clinton 1							80			80			81		1	81	5		81			1	76
2. Clinton 2							82	83		83		1	84		1	84	0		88		4	6	76
3. Blue Hills 1							81			83		2	85		2	89		4	89			8	
4. Millstone 3							80			80			79		-1	82	10	3	82			2	74
5. Pebble Springs 1										81			83		2	85		2	85			4	
6. Allens Creek 1[1]							80			80						85		5	85			5	
7. Perkins 1							81	83		83		1	83			85		2	85			3	
8. Perkins 2							81	84		85		3	85			87		2	87			5	
9. Perkins 3							81	84		87		5	87			89		2	90		1	8	
10. Cherokee 1							82	84		84		1	84			84	<1		84			1	
11. Cherokee 2							82	84		86		3	86			86	<1		86			3	
12. Cherokee 3							82	84		88		5	88			88	<1		89		1	6	
13. Jamesport 1							81			81			82		1	83		1	84		1	3	
14. Future 1[2]										81			83		1	85		2	87		2	5	
15. Future 2										82			84		2	87		3	89		2	7	
16. South Texas 1							80			80			80			80	2.5		80				75
17. South Texas 2							82			82			82			82	<1		82				75
18. WPPSS 3							81			81			81			83		2	83			2	
19. River Bend 2				81			82			82			83			83	1		85		2	2	77
20. Palo Verde 1							81			81			82		1	82			82			1	76
21. Palo Verde 2							83	5		82		-2	84		2	84			84				76
22. Palo Verde 3							83	5		84			86		2	86			86			2	76
23. 1990 Unit[3]							85			90		5	90			90			90			5	
24. 1992 Unit							86			92		6	92			92			92			6	

-CONTINUED-

UNITS ORDERED IN 1973

-CONTINUED-

PLANT	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	TOTAL DELAY 1970-1977	YEAR CP ISSUED
	1971			1972			1973			1974			1975			1976			1977				
25. Black Fox 1							82			83		1	83			83			83			1	
26. Black Fox 2							84			85		1	85			85			85			1	
27. Skagit 1							83			81		-2	82		1	83		1	84		1	1	
28. Callaway 1							81			81			81			81			82		1	1	76
29. Wolf Creek							81			82		1	82			82			83		1	2	
30. Tyrone 1							82			85		3	85			84		-1	84			2	
31. Callaway 2							83			83			83			83			87		4	4	76
32. Sterling 1										82			84		2	84			84			2	
33. Davis-Besse 2							81			81			83		2	83			85		2	4	
34. Davis-Besse 3							83			83			85		2	85			87		2	4	
35. Allens Creek 2							82			82													
36. Somerset 1[4]										84			86		2				88		2	4	
37. Somerset 2										86			88		2				90		2	4	
38. Tyrone 2					N	O		I	N	F	O	R	M	A	T	I	O	N					
39. Boardman [5]					C	A	N	C	E	L	E	D		I	N		19	74					
Aggregate Delays (Years)												34			25			28			28	115	

1. Units 1 and 2 were deferred in September of 1975. Unit 1 was reactivated in October of 1976. Unit 2 was canceled.

2. Formally Koshkonong 1, 2, alternative sites under consideration.

3. Corresponds to former AGS 3, 4.

4. NYSG & E, 1200 MW, GE-BWR, announced 7/13/73, later known as Nuclear Unit 1, 2 (New York).

5. Portland GE, 1260 MW, B & W - PWR, Portland Oregon was announced on February 16, 1972.

APPENDIX C

UNITS ORDERED IN 1974

PLANT	1972			1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
1. Zimmer 2				78			84		6				87		3	87			9	
2. Jamesport 2				84			83		-1	84		1	85		1	86		1	2	
3. NEP 1							82			83		1	84		1	84			2	
4. NEP 2							83			85		2	86		1	86			3	
5. Pebble Springs 2							83			85		2	88		3	88			5	
6. Blue Hills 2				83			85		2	87		2	91		4	91			8	
7. Green County													84		1	84			1	
8. Montague 1				81			82		1	86		4	86			86			5	
9. Montague 2				83			84		1	88		4	88			88			5	
10. Carolina P & L 8													87			87				
11. Carolina P & L 9													89			89				
12. Carolina P & L 10																				
13. WPPSS 4							82			82			83	1	1	83			1	
14. WPPSS 5							83			83			84		1	85		1	2	
15. Marble Hill 1													82			82				
16. Marble Hill 2													84			84				
17. Skagit 2							83			85		2	86		1	86			3	
18. Yellow Creek 1[1]							82			83		1	85		2	85			3	
19. Yellow Creek 2							83			84		1	86		2	86			3	
20. Phipps Beach 1							83			83			84		1	84			1	
21. Phipps Beach 2							84			84			85		1	85			1	

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APPENDIX C

UNITS ORDERED IN 1974

-CONTINUED-

PLANT	1972			1973			1974			1975			1976			1977			TOTAL DELAYS 1970-1977	YEAR CP ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
22. Fort Calhoun 2										83			83			83				
23. NORCO-NP 1							81			85										
24. Sears Island										84			86		2				2	
25. Barton 3							85	C	A	N	C	E	L	E	D		19	76		
26. Barton 4							86	C	A	N	C	E	L	E	D		19	76		
27. Florida Power 2							*	C	A	N	C	E	L	E	D		19	76		
28. Florida Power 3							*	C	A	N	C	E	L	E	D		19	76		
29. Iowa Power and Light							83	C	A	N	C	E	L	E	D		19	76		
30. St. Rosalie 1							82	C	A	N	C	E	L	E	D		19	75		
31. St. Rosalie 2							84													
32. Offshore 1 & 2				C	A	N	C	E	L	E	D									
Aggregate Delays (Years)									9			20			25			2	56	

1. Site moved from Atlanta to Mississippi.

2. Site undetermined.

*Indefinite.

APPENDIX C

UNITS ORDERED IN 1975

PLANT	1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
1. Sun Desert 1							85			84		-1	85		1		
2. Sun Desert 2							88			86		-2	86				
3. South Dade 1							83										
4. South Dade 2							85										
Aggregate Delays (Years)																	

UNITS ORDERED IN 1976

PLANT	1973			1974			1975			1976			1977			TOTAL DELAY 1970-1977	YEAR CP ISSUED
	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year	Expected Date of Commercial Operation	Percent Progress	Delay in Commercial Op. vis-a-vis Previous Year		
1. Vandalia[1]										85							
2. Erie 1										84			86		2	2	
3. Erie 2										86			88		2	2	
Aggregate Delays (Years)															4	4	

1. Previously Central Iowa Nuclear Unit.

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